Inquiring Astronomy: Incorporating Student-Centered Pedagogical Techniques in an Introductory College Science Course

By Debbie A. French and Andrea C. Burrows

Increases in student-centered pedagogy have been more prevalent in K–12 education than in collegiate undergraduate science education. The purpose of this study was to determine the effects of using student-centered pedagogy advocated in K–12 education on introductory astronomy students' content knowledge, interest, and recall of content taught in the semester. Forty-two students participated in the study and took the Test Of Astronomy STandards (TOAST) at the beginning and end of the semester. The students had an average initial TOAST score of 37% and a post-TOAST score of 62%. Students also participated in surveys reporting their interest in astronomy, whether their interest in astronomy changed, and what they remembered from the course. Students (79%) reported the class increased their interest in astronomy in a survey given at the end of the semester. Students reported remembering the active-learning activities more than astronomical facts. These results show encouraging results for creating and implementing student-centered pedagogical techniques in college science courses of all disciplines.

For physicist Richard Feynman (1999), science was about experiencing the "pleasure of finding the thing out, the kick of discovery" (p. 2). Despite Feynman's romanticization of science, lecture is the most prevalent teaching technique in college. Many introductory college science courses present science as a collection of facts and teach the history of science; such environments do not provide an opportunity for students to construct knowledge and learn the joy of discovery (Crawford, 2014; Duschl, 1990). Teaching K–12 science by implementing student-centered teaching techniques such as active learning and inquiry has been the focus of national science education reform documents published by the National Research Council (1996, 2000), and most recently with the *Next Generation Science Standards* (*NGSS*; NGSS Lead States, 2013), but student-centered pedagogy has received less attention at the college level.

Introductory astronomy, often referred to as Astro 101, is a common introductory science class for students to chose, especially for nonscience majors. The number of students enrolled in Astro 101 in the United States from 1998 to 1999 was estimated to be 250,000 but has now risen to 500,000 (Fraknoi, 2002; Prather, 2013). This equates to approximately 20% of all college students taking Astro 101 during their undergraduate career; up to 25% of these students become STEM (science, technology, engineering, and mathematics) majors, and many of these students (up to 40%) will eventually select education as a major (Lawrenz, Huffman & Appeldoorn, 2005; Partridge & Greenstein, 2003; Prather, 2013).

Literature review

Teaching science using student-centered instruction such as inquiry has many definitions and can range from teacher directed to student driven (Martin-Hansen, 2002; National Research Council, 2000). This study uses the following description: "In a student-centered curriculum, learning science is active and constructive, involving inquiry and hands-on activities" (Taraban, Box, Myers, Pollard, & Bowen, 2007, p. 961). An analysis of 138 studies from 1984 to 2002 revealed an increase of science instruction using student-centered pedagogy within grades K–12 (Minner, Levy, & Century, 2010). Released in 2013, the *NGSS* (NGSS Lead States, 2013) place an emphasis on student-centered pedagogical techniques such as authentic scientific inquiry—a form of inquiry more closely following the practices of scientists. Students are expected to merge content knowledge, their understanding of cross-cutting concepts, and science and engineering practices to successfully demonstrate the *NGSS* student performance objectives. More students are coming to introductory college science classrooms with prior inquiry experience but often find introductory college classes are still taught using traditional teaching methods such as lecture and cookbook-style labs (Crawford, 2014).

College science faculty value inquiry-based instruction, but many faculty are hesitant to implement inquiry-based strategies because of such concerns as "limitations of time, class size, student motivation, and student ability" (Brown, Abell, Demir, & Schmidt, 2006, p. 784). Faculty surveyed frequently viewed inquiry as not being appropriate for introductory science classes and nonscience majors (Brown et al., 2006). Physics and astronomy "majors and nonmajors alike are discouraged by poor pedagogical techniques" (Partridge & Greenstein, 2003, p. 8). Students who are nonmajors are often not interested in science because they see only what Duschl (1990) refers to as *final form science*—science facts that are the result of scientific inquiry; students do not get to see scientific inquiry as a process or get to participate in that process.

Teaching science by inquiry, however, can be a powerful tool to get students interested in science (Crawford, 2014). Inquiry and active learning techniques were shown to increase students' conceptual understanding more than traditional lecture-based instruction (Minner, Levy, & Century, 2010). In a 2014 analysis of 225 studies, researchers found a 6% increase in student exam scores in undergraduate STEM courses implementing active learning techniques (Freeman et al., 2014). This analysis also revealed students in a lecture-based STEM course had a failure rate of 1.5 times that of an active learning course (Freeman et al., 2014). Undergraduate science students increased their critical-thinking abilities as a result of science faculty implementing active learning techniques in the undergraduate science courses (Kim, Sharma, Land, & Furlong, 2012). Another study described college instructors that initially chose to implement teacher-centered (guided) inquiry projects, but once they saw the students' increased ability to apply their knowledge, these instructors intended to incorporate more inquiry in their classes (Yarnall & Fusco, 2014).

Although teaching by inquiry at the college level remains less common than in grades K–12, research on college science classes implementing best practices from K–12 science education such as active learning, inquiry, problem or project-based learning, or collaborative learning groups show encouraging results. For example, Metoyer, Miller, Mount, and Westmoreland (2014) showed team-based learning, a type of cooperative learning, when incorporated in college science and science education classrooms, "increased student performance, attention, participation, interaction with peers, practice with higher levels of thinking, and positive attitudes toward science" (2014, p. 46). In another study, incorporating student-centered pedagogies increased introductory astronomy students' achievements and interest in the course (Christensen, 2005). This gave the instructor an opportunity to tailor instruction to meet these students' learning needs (Christensen, 2005). The researcher also cited benefits to the instructor such as being able to uncover students' thought processes and perceptions prior to

TABLE 1

Student data.

Astro 101 (fall 2015)					
Class	Freshman	Sophomore	Junior	Senior	
	21 (34%)	17 (27%)	14 (23%)	10 (16%)	
Gender	Female	Male			
	26 (42%)	36 (58%)			
Major	STEM	Non-STEM	Education	Fine arts	Undeclared
	14 (23%)	30 (48%)	8 (13%)	9 (15%)	12 (19%)

Note: N = 62. The percentages for student majors add to over 100% because of students declaring a double major, such is as required for secondary education majors.

TABLE 2

Physics, chemistry, and content incorporated in Astro 101.

Physics	Chemistry	Biology	Earth science
Newton's Laws of Universal Gravitation	Bohr model of the atom	Exoplanet habitable zone	Planetary geology
Newton's Laws of Motion	Atomic spectra	Extremophiles	Greenhouse gases
	Cosmic origins of the Periodic Table of the Elements		Atmospheric transmission of parts of the electromagnetic spectrum

TABLE 3

Active-learning and inquiry-based learning activities completed in Astro 101.

Activity title	Activity description	Interdisciplinary connections	Source
Kinesthetic Astronomy	Students moved through Earth's rotation, revolution, and simulated Earth's seasons. Students learned about the night sky in China, Zodiacal constellations.	**Biology:** Seasonal behaviors of plants and animals due to amount of sunlight **Chemistry:** Color changes in leaves due to change in sunlight. **Earth/Environ. Science:** Seasons and weather patterns, amount of daylight **Physics:** Rotation, revolution	Zawaski and Morrow (2004)
Phases of the Moon	Students modeled moon phases outside using a Styrofoam ball. Students kinesthetically learned waxing/waning by "waxing on" with their right hand, and "waning off" with their left hand in tune to a similar disco song. Students modeled differential rotation of the moon.	**Biology:** Tides **Earth/Environ. Science:** Tides **Chemistry:** Spectral analysis of sunlight reflected from moon **Physics:** Rotation, revolution	1. Night Sky Network (2008a) 2. M. J. Krech (n.d.)
Debunking Astrology	Students read a horoscope of a different sign and were asked whether it applied to their life. Students then read the correct sign. Students were asked whether the *correct* horoscope applied to their life. Fewer hands were raised for the *correct* horoscope. The 13 Zodiacal constellations, astrology origins, and why astrology was a pseudoscience were discussed.	Any class wishing to demonstrate science vs. pseudoscience **Math:** Statistics	D. French
Pocket Solar System	Students created a rough scale of the solar system using an arm's length of cash register tape.	**Biology:** Habitable zones **Chemistry:** Planet chemistry, temperature and the formation of the solar system **Physics:** Kepler's Laws of Planetary Motion	Night Sky Network (2008b)
Electromagnetic Spectrum	Students experimented with parts of the electromagnetic spectrum by calculating the speed of light with a microwave and a chocolate bar, and do color perception investigations which were connected to astronomical image processing.	**Biology:** Color perception, vision **Chemistry:** Fluorescence **Earth/Environ. Science:** UV Mineral identification and soil compositions **Physics:** Wave properties, transmission of light	D. French
Doppler Effect/ Slinky Demo	A Slinky was used to demonstrate the Doppler effect	**Biology:** Hearing, echolocation in bats **Chemistry:** Spectroscopy of moving sources **Earth/Environ. Science:** Doppler detection of underground features **Physics:** Wave behavior	D. French
Newton's Laws Stations	Students visited stations representing Newton's Laws. For example, a plastic cube balanced on top of a hoop to falling into a plastic bottle (inertia).	**Biology:** Reaction time, balance **Physics:** Force, inertia, momentum, mass, weight	J. Moore (2008)
Measuring the Mass in a Galaxy	Students used the Law of Universal Gravitation to calculate the amount of dark matter in galaxy NGC 2742.	**Chemistry:** Element spectra **Physics:** Doppler shift, universal gravitation	Indiana University

TABLE 3 (Continued)

Active-learning and inquiry-based learning activities completed in Astro 101.

Activity title	Activity description	Interdisciplinary connections	Source
Atomic Spectra/ Electron energy transitions	Instructor used the ground, chair, and table to represent electron energy levels for the Balmer hydrogen series. The instructor tossed a purple, teal, or pink ball (representing the color of a photon) when dropping to the appropriate level. The instructor would catch a *photon* of the appropriate color to move up a energy level(s).	**Biology:** Color perception **Chemistry:** Atomic spectra, Bohr model of the atom **Physics:** Wave properties, color defined by wavelength	D. French
Exoplanet Wobble	Students investigated the effects an exoplanet would have on its parent star by attaching small, medium, and large-massed marbles to a golf tee and fixing the tee in a foam ball. Students then developed testable questions.	**Biology:** Habitable zone **Physics:** Orbital mechanics, angular momentum, Doppler shift	Night Sky Network (2011a)
Extremophiles	Students formed colonies of extremophiles found on Earth. Using the room as a scale, students moved around room to visualize the living conditions of their extremophile (temperature, pressure, light, water, etc.).	**Biology:** Extremophiles, requirements for life **Chemistry:** Chemical requirements for extremophiles **Earth/Environ. Science:** Extreme environments on Earth **Physics:** Pressure	Night Sky Network (2011b)
Hydrostatic Equilibrium	A Hoberman sphere was used to demonstrate hydrostatic equilibrium. Students related surface area to luminosity in PMS stars.	**Biology:** Habitable zones **Chemistry:** Chemical abundances of stars **Physics:** Surface area to Luminosity ratio	D. French
Expansion of the Universe	A Hoberman sphere was used to demonstrate the expansion of the universe.	**Chemistry:** The astronomical sources of non-synthetic elements **Earth/Environ. Science:** Ages of Universe and Earth **Physics:** Hubble's law	D. French
Black Holes	A large mass was placed on stretchy fabric and a hoop to represent space time. Students experimented with different different masses of beads to simulate orbiting stars.	**Biology:** Spaghettification—what happens to humans as they travel near a black hole **Physics:** Orbital mechanics	D. French
Lecture-Tutorials	A few Lecture-Tutorials of various topics were used throughout the course.	Nature of science, analysis of data, use of evidence in argumentation	Prather, Slater, Adams, and Brissenden (2012)
Galaxy Chocolate Chip Pancakes	Students calculated the weight percentage of a pancake recipe and compared it to the weight percentage of a galaxy recipe.	**Biology:** Determine if elements needed for life are present in galaxies. **Chemistry:** Calculating weight percent, Elements in galaxies **Physics:** Spiral galaxy structure	L. V. Jones (personal communication, 2001).

Note: Sources are listed to the best of the authors' knowledge.

instruction. Additionally, an Earth science course for elementary teachers with little initial Earth science knowledge that incorporated more student-centered learning activities was shown to expand these students' knowledge base (Avard, 2009). One common theme emergent from these studies is that incorporating student-centered pedagogies in a large lecture-based course is a gradual process.

Because up to 40% of Astro 101 students nationwide eventually become education majors, it is important that inquiry teaching methods are modeled, as research has shown that teachers teach according to how they were taught (Partridge & Greenstein, 2003; Prather, 2013; Loucks-Horsley, Hewson, Love, & Stiles, 1988). The *NGSS* emphasize having K–12 students conduct authentic scientific inquiry and science and engineering practices (National Research Council, 2012). Therefore, teachers will be expected to teach science through student-centered pedagogical practices such as inquiry. If these teachers are only taught science through lecture-based instruction, teaching science using student-centered pedagogical techniques will be difficult at best (Crawford, 2014; Loucks-Horsley et al., 1998).

Gap in the literature

Because of the tacit assumption that teachers teach according to how they were taught, Crawford (2014) proposed the following question: "How can undergraduate science courses be redesigned to help prospective teachers understand inquiry/practices and nature of science?" (p. 573). This question has been previously asked in reform documents such as *Taking Science to School* and, more recently, the *NGSS* Framework, but it has received considerably less attention at the college level (Duschl, Schweingruber, & Shouse, 2007; National Research Council, 2012). Therefore, because up to 40% of Astro 101 students eventually become education majors, an inquiry-based Astro 101 course is the focus of this study.

Research questions

How does incorporating student-centered pedagogical techniques lead to students' broader understanding of introductory astronomy as evidenced by a standardized astronomy test score? Did the implementation of student-centered pedagogical techniques change students' interest in astronomy? Finally, what did students self-report that they remembered from this class?

Method

Participants

Participants were enrolled in an introductory survey of astronomy course in the fall 2015 semester at a doctoral-granting, research extensive, land-grant university in the Western United States. Graduate assistants taught the accompanying laboratory component. Sixty-two students were actively enrolled in the course, and the average attendance was 84% as evidenced by participation grades taken from in-class activities with average laboratory attendance at 77%. Forty-two students participated in this study. Table 1 describes the demographics of the participants, which are similar to the university student population overall.

Course description

Because Astro 101 is a terminal science class for many students, it is also important to include connections to other science disciplines (Partridge & Greenstein, 2003). Table 2 shows the other science content incorporated into this class.

Following the recommendation in *How Students Learn* (Donovan & Bransford, 2005), lecture was used in conjunction with inquiry-based and active learning strategies to give requisite background information, review the learning goals for the activity, and connect the lesson to broader science concepts for which novice students may not see such connections (Donovan & Bransford, 2005). The course was designed to include recommendations made in *Goals for "Astro 101": A Report on Workshops for Department Leaders,* a report commissioned in 2003 by the American Astronomical Society (AAS) on best teaching practices for Astro 101 (Partridge & Greenstein, 2003). This is the most recent report published by the AAS on this topic.

The instructor incorporated many student-centered pedagogical strategies such as active and inquiry-based learning, and this decision was made on the basis of the instructor's 11 years of experience as a science teacher and a science teacher educator. Examples of these student-centered activities included Kinesthetic Astronomy (Morrow & Zawaski, 2004), Life in the Extreme (Night Sky Network, 2011b), Exoplanet Wobble simulation (Night Sky Network, 2011a), Newton's Laws Activity Stations, Measuring the Mass of a Galaxy (Indiana University, n.d.), and a few Lecture-Tutorials (Prather, Slater, Adams, and Brissenden, 2013). Lecture-Tutorials are a pedagogical method where students listen to a lecture, then collaboratively answer questions on that topic. Instructors can use activities such as these as tools to move students through the steps of desired learning progressions (T. F. Slater, Burrows, French, Sanchez, & Tatge, 2014).

Although courses implementing only Lecture-Tutorials have reported increased learning gains, research has shown higher learning gains for pedagogical techniques that incorporate more collaborative and student-centered pedagogy (Chase, 2014; Eckenrode, Prather, & Wallace, 2016; Gonzales, 2014). In Astro 101, students had the opportunity to work collaboratively on all of the activities, and the instructor walked around the room, using formative assessment to check for student understanding and address any questions. Table 3 lists the student-centered learning activities.

Because Astro 101 may be the last science course students take, connections to other science disciplines such as biology, chemistry, Earth and environmental science, and physics were emphasized in these student-centered activities. The interdisciplinary connections are shown in Table 3. Instructors of other disciplines may wish to incorporate these activities into their science curriculum regardless of their discipline.

To determine whether student-centered teaching methods lead to students' broader understanding of introductory astronomy, students took the Test Of Astronomy STandards (TOAST) at the beginning and at the end of the semester. The (TOAST) contains 27 multiple-choice questions over the range of topics traditionally taught in an introductory astronomy course (S. J. Slater, 2014). The TOAST was selected for this study because the "scientific content represents a consensus of expert opinion about what students should know from three different groups: the American Association for the Advancement of Science, the National Research Council, and the American Astronomical Society" (S. J. Slater, 2014, p. 1). Additionally, the test is sensitive enough to detect differences in education and experience between groups such as professors, inservice teachers, and students, and the TOAST has been determined to be valid and reliable (S. J. Slater, 2014). The Cronbach's alpha for the TOAST data from this study is 0.755. Normalized gain scores were calculated and compared with the gain criteria presented by Prather (2013). A dependent *t*-test was also calculated to determine if the difference in means of pre-TOAST and post-TOAST scores were statistically significant. The post-TOAST scores were then compared with the national average for college students, in-service teachers, and teachers who have taken astronomy education professional development. The Astro 101 students' mean score was 44% pre-instruction (n = 1,066) (S. J. Slater, 2014). By comparison, the average in-service teacher score was 66% (n = 519) (Stork, 2014). Additional TOAST data from a lecture-based course is being collected currently for future comparison of these data.

To provide additional context, students were asked to identify 10 things that they best remember from the course by completing an open-ended survey at the end of the semester. Student responses were tallied by theme, and the results are discussed in the following section. Students were also asked to complete a short survey of their interests in astronomy before and after taking the course. Questions from this survey included whether the course increased their interest in astronomy and whether they were more likely to watch a science documentary or pick up a popular astronomy magazine. Students' responses are provided in Table 5. The Cronbach's alpha for these data is 0.627.

TABLE 4

Comparison of mean pre- and post-TOAST scores.

TOAST scores	*n*	*M*	*SD*	*t*	*df*	*p*
Pre	42	10.05	4.143	11.044	41	0.000
Post	42	16.64	4.3110			

Note: TOAST = Test Of Astronomy STandards.

Results

Statistical significance between pre- and post-TOAST scores

The results of the *t*-test for dependent samples are presented in Table 4 and indicate a statistically significant difference, $t(41) = 11.04$, $p < .05$, between pre-TOAST ($M = 10.05$, $SD = 4.143$) and post-TOAST scores ($M = 16.64$ (62%), $SD = 4.310$) for the fall 2015 Astro 101 class.

Normalized TOAST score gains

To appreciate how much students learned by the end of the semester, with respect to their pre-TOAST scores, the normalized gain for each student was calculated. The normalized gain scores are given in Figure 1. Fourteen (33%) students achieved low-learning gains ($g < 0.3$), 24 (57%) achieved moderate-learning gains ($0.3 < g < 0.7$), and 4 (10%) achieved high-learning gains ($0.7 < g$).

What students remembered

When students were asked to report the top 10 things they remembered from this class, their responses fell into two categories: class activities and interesting facts. The authors included only responses that were mentioned at least 10 times. There were 192 instances of students recalling active learning activities, such as (a) Galaxy Pancakes, (b) Spectra demonstration, (c) Size and Scale of the Solar System, (d) Kinesthetic astronomy, (e) Newton's Laws Stations, (f) Extremophiles, (g) EM Spectrum activities, and (h) *wax on, wane off* for moon phases. There were 145 instances of students recalling interesting facts (mostly interesting facts about the lives of scientists, planets, space travel, stellar evolution, and constellations). Often, students explained what they learned from student-centered activities in their responses, such as (a) "I got a relative sense of distance between planets with the receipt paper project," (b) "electrons shifting levels with you standing on tables and throwing stuff [small rubber balls representing the color of photons] at us," (c) "the most important thing to look for on other planets to determine if there might be life is water," (d) "phases of the moon . . . I will always remember *wax on* with my right hand," and finally, (e) "I remember going outside and mimicking the Earth's orbit around the sun."

Students' interest in astronomy

Table 5 reveals positive student interest with astronomy before and after taking this course. The majority of students felt this course increased their overall interest in astronomy, or their interest stayed the same.

Implications and conclusions

Because it is estimated that over one third of students enrolled in Astro 101 eventually become education majors and research has shown that teachers teach according to how they were taught, modeling student-centered pedagogical techniques is critical for student exposure to purposeful activities leading to science learning (Crawford, 2014; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Prather, 2013; Partridge & Greenstein, 2003). But does a student-centered Astro 101 course adequately provide most students with a solid understanding of what students should learn from taking the material? The average TOAST posttest score for participants in this study was 16.41 (62%), an increase of 25% from pre-TOAST scores. These undergraduate students achieved higher TOAST scores than typical undergraduate students after taking Astro 101 and inservice teachers, and comparable to in-service teachers with extra astronomy education training (S. J. Slater, 2014).

Incorporating student-centered pedagogy

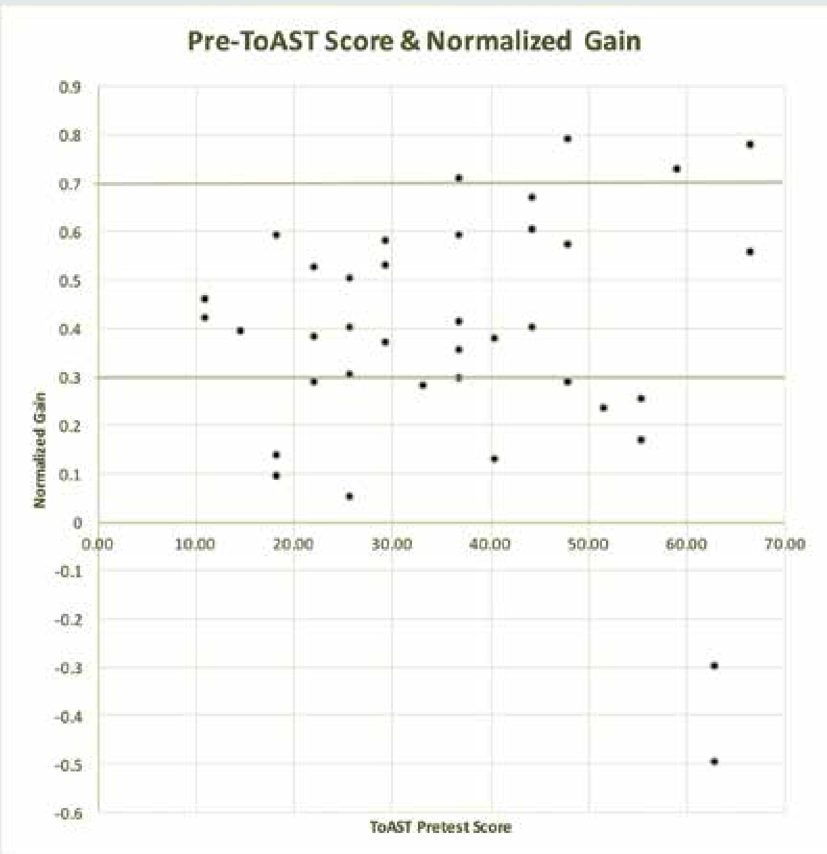
Incorporating student-centered pedagogy into a traditional science classroom may be done gradually. Some strategies to incorporate more student-centered teaching techniques into any college science classroom include the following suggestions. First, examine existing lessons to determine how the lessons could be made more student centered, and use Table 3 as a starting point. Second, select a few activities to begin implementing in a course on the basis of the content and main science topic(s) to be taught, and add additional activities gradually over semesters and years. Some ideas for starting small include incorporating techniques such as think-pair-share, collaborative learning, Lecture-Tutorials, and/or hands-on activities. Consider implementing memorable interactive lecture demonstrations such as standing on a chair and table to explain atomic spectra and the Bohr model of the atom, or use a Hoberman sphere to demonstrate hydrostatic equilibrium in stars or the expansion of the universe. More advanced strategies include incorporating kinesthetic activities where students move to model physical phenomena (e.g., Kinesthetic Astronomy, *wax on, wane off* for moon phases). Third, consider how models (such as the Exoplanet Wobble activity) can be incorporated into the existing curriculum, and as an extension have students make predictions, test those predictions, and develop explanations and questions based on their investigation(s). Ask the class to work in collaborative groups to make predictions and develop explanations throughout the demonstration as suggested by Adams, Brissenden, Lindell, Slater, and Wallace (2002). Finally, include education departments in conversations regarding implementing research-based student-centered teaching practices and associated student learning outcomes. Ask, "What do I want my science students to know and be able to do?" and "How will I give them practice to get there?" Although some initial prep work was involved with these activities (less than 15 hours), once the materials (total cost of $100) were gathered and prepared, they can be used for future classes.

This study shows a statistically significant increase in student learning gains, students' increased or maintained interest in the subject, and student remembering of active learning experiences more than "fun facts" in the science course. These data show encouraging results for implementing student-centered learning practices in the college undergraduate science class to promote long-term learning instead of short-term test memorization.

Modeling to provide high-quality, engaging science instruction is important for all college students. It is particularly important for Astro 101 professors to be cognizant of this fact because many Astro 101 students eventually declare an education major. These results also apply to other science disciplines, as many college faculty perceive inquiry as inappropriate for nonscience majors and introductory science classes (Brown

FIGURE 1

Normalized gain scores.



et al., 2006). There is a disconnect between how these college students are taught science using teacher-centered instruction such as lecture and how they will be expected to teach using student-centered instruction such as active learning and inquiry (Crawford, 2014). Quality science instruction should include rigorous learning goals as well as engaging instructional techniques. The findings of this study show high student learning gains as evidenced by a class average of a 62% post-TOAST score, and these learning gains can be obtained by other Astro 101 instructors (and those from other science disciplines).

When students were asked to recall the 10 things that they remembered from the course, they responded with the active learning experiences—things these students had the opportunity to do in the course. Students may not recall reading a particular chapter, completing a homework set, doing a worksheet, or completing a cookbook lab. However, students will recall the positive experiences and engaging activities that they participated in during the science classes. Science instructors need to ask whether teaching final-form science or the history of science is more important than allowing students, as Feynman describes, "The pleasure of finding the thing out" (1999, p. 12).■

Acknowledgments

The authors thank the student participants of the Astro 101 class and acknowledge partial to full funding, as well as activity trials, for this study from the following grants: Launching Astronomy Standards and STEM Integration (LASSI) and Collaborative Research: The Hidden Side of Rapidly Growing Black Holes: Host Masses and Evolution of Obscured Quasars with SDSS and WISE. The first author would like to thank Dr. T. F. Slater for his support with Astro 101.

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TABLE 5

Students' interest in astronomy.

Question	Agree	Neutral	Disagree	Question	Agree	Same as before	Disagree
I enjoy learning about astronomy.	49	4	0	After taking this course, I enjoy learning about astronomy more.	45	8	0
I enjoy watching science programs on TV (e.g., Nova, PBS, Cosmos, etc.).	31	18	4	After taking this course, I am more likely to watch science programs on TV.	29	22	2
I feel I understand science programs.	42	10	1	After taking this course, I feel I understand programs better.	40	10	3
I enjoy reading an astronomy magazine or book.	18	28	7	After taking this course, I am more likely to pick up an astronomy magazine or book.	24	23	6

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