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A Life in the Universe Survey

Michael C. LoPresto
Henry Ford Community College, Dearborn, Michigan 48128
Jennifer Hubble-Zdanowski
Henry Ford Community College, Dearborn, Michigan 48128
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Abstract

The "Life in the Universe Survey" is a twelve-question assessment instrument. Largely based on the factors of the Drake equation, it is designed to survey students' initial estimates of its factors and to gauge how estimates change with instruction. The survey was used in sections of a seminar course focusing specifically on life in the universe where it was designed and validated as well as in sections of introductory astronomy where life in the universe is only a single topic covered at the end of the semester.

1. INTRODUCTION

What follows is a report on the development, validation, and implementation of a brief survey on student ideas pertaining to the subject of life in the universe. The "*Life in the Universe*" survey was developed and validated in an honor's seminar course on the subject of life in the universe then implemented in both a subsequent section of the seminar course and in several sections of introductory astronomy.

THE SURVEY

Life in the Universe Survey

Select the choice that best agrees with what YOU think.

1. About how many stars are there in our galaxy?
   A. A few hundred
   B. A few hundred thousand
   C. A few hundred million
   D. A few hundred billion
   E. A few hundred trillion
2. Approximately what percentage of the stars in our galaxy have planets in orbit?
   A. Very few stars have planets in orbit
   B. 20%
   C. 40%
   D. 60%
   E. 80%–90%
3. On average, how many habitable (Earth-like) planets are there per planetary system?
   A. Very few (not even one in every solar system)
   B. 1
   C. 2 or 3

D. 4 or 5
E. More than 5

4. On what fraction of habitable planets will life develop?
A. A very small percentage, life is very rare
B. 20%
C. 50%
D. 80%
E. 100%, if conditions are favorable, life is inevitable

5. On what fraction of planets on which life develops will life evolve to intelligence?
A. A very small percentage
B. 1%–10%
C. 50%
D. 80%
E. 100%

6. What fraction of planets on which life evolves to intelligence will the intelligence develop a technological civilization capable of radio communication?
A. <1%
B. About 10%
C. 20%–30%
D. 50%–60%
E. 100%, a technological civilization will always eventually develop if life is present

7. What is the average lifetime of a technological civilization capable of communication?
A. 100 yr
B. 1000 yr
C. 10 000 yr
D. 100 000 yr
E. 1 000 0000 (million) yr or more

8. What are the chances that we on Earth will someday communicate with an extraterrestrial civilization?
A. Almost none, it is nearly impossible
B. Remote at best, it is very unlikely
C. It is possible, but unlikely
D. It is probable
E. It has likely already happened

9. What is the most likely way to detect or communicate with life elsewhere in our galaxy?
A. Through manned spaceflight
B. With a robot spacecraft
C. By telescopic observation of their planet
D. The detection of radio signals
E. This is impossible

10. If we ever do encounter extraterrestrial beings, they will most likely be
A. similar to humans and friendly
B. similar to humans but hostile
C. different than humans but friendly
D. different than humans and hostile
E. unrecognizable

11. If we ever do encounter extraterrestrial beings, their technology will most likely be
A. much more advanced than ours
B. somewhat more advanced than ours
C. similar to ours
D. less advanced than ours
E. much less advanced than ours

12. If we ever do contact intelligent extraterrestrial beings, who should speak for Earth?
A. Religious leaders
B. Government and military leaders
C. Scientists
D. Ordinary citizens
E. No one should talk to them because contact could be too dangerous

2. DEVELOPMENT

The life in the universe survey was developed in an honor's seminar course taught on the subject of life in the universe. The survey is based largely on the Drake equation, which was the main subject of the first half of the course. Early in the semester, students, working in groups with the aid of a website (see Note-1), were introduced to the Drake equation, made group estimates for each factor, and then with the aid of the website calculated a value for the number of civilizations in our galaxy with which contact may be possible.

Throughout the first half of the course, students heard lectures from guest speakers (instructors of different disciplines) on topics relevant to the Drake equation factors:

Astronomy—Extra Solar Planets
Geology—Earth's Origin and Environment
Chemistry—Prelife Chemistry
Biology—Origin of Life; Evolution of Life
Psychology—Intelligence
History—Civilization and Technology
Environmental Science—Environmental Hazards
Microbiology—Biological Hazards
History—War, Science and Technology.

They also read articles from two collections of articles on the various aspects of life in the universe related to many of the topics covered by the speakers and the Drake equation factors from the popular magazine *Scientific American* (Staff Editor 1994, 2002).

Students were required to write essays on each factor in the Drake equation including an estimate for the factor and how they arrived at it based on what they had learned from the speakers and readings. Ultimately, they would weave together a term paper from the essays that culminated with a determination of their own final value for N, the number of civilizations in our galaxy with which communication is possible.

The first eight questions of the twelve-item survey came directly from the seven factors and final product of the Drake equation

$$N = N^{*} f_p n_e f_l f_i f_c f_L,$$

where N^* is the number of stars in the Milky Way Galaxy, f_p is the fraction of stars that have planets in orbit, n_e is the number of habitable planets per star (planets capable of sustaining life), f_l is the fraction of habitable planets on which life actually originates, f_i is the fraction of planets with life where intelligent life evolves, f_c is the fraction of planets with intelligent life that develop the technology to communicate, f_L is the fraction of the planet's life during which a communicating civilization survives, and N is the final product; the number of civilizations in the galaxy with which communication is possible.

None of the Drake equation factors have a precisely known value (even the first factor, the number of stars in the Milky Way Galaxy, has only an accepted order of magnitude estimate) and the values become more and more speculative for each successive factor.

The choices for the five-item multiple-choice responses for the first eight items were selected based on histograms constructed from student responses to the above-mentioned group project at the beginning of the semester and their estimates for each Drake equation factor in their essays during instruction. Generally, the median (which was usually also the mean) value was used for choice "c," with choices "b" and "d" being other commonly occurring estimates above and below the median but not at the extreme. Choices "a" and "d" were saved for the extreme choices, one or both of which were often the mode.

For instance, in items 4–6 of the survey on what fraction of planets life will develop, evolve to intelligence, and develop a technological civilization, choice "a" was always a very small value, representing few or none, while "e" was 100%—that it was inevitable. These two extremes, as shown in Figure 1, were usually the two most common responses.

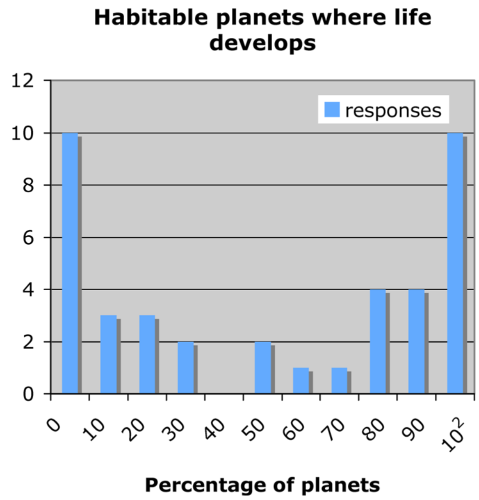


Figure 1. Histogram used to select choices for item 4; median = between 50/60; mean = 52, modes = 0 and 100

The final four items of the survey were based more on the second half of the course in which speculation about the implications of contact was a large part. Item nine came from coverage of Project SETI and item 10 largely from what was learned about the origin and evolution of life in the first half of the course, but also somewhat from science fiction featuring "aliens." The same is true for item 11. Item 12 came directly from the viewing of the movie version of Carl Sagan's novel (1985) "*Contact*" that began the second half of the course.

Choice "e" in item 12, that we should not contact extraterrestrials because it may be too dangerous, was suggested by one of the introductory astronomy instructors who would be giving the survey to the sections he was teaching. He cited polling he had done that suggested this was a common concern among students, approaching 40%. That instructor also suggested the addition of item "e" in item 8. He again cited polling in his sections that indicated nearly 40% of his students believed that contact with extraterrestrial life had already occurred but it was not generally known due to government cover-ups.

3. VALIDATION

The survey was first given as an "exit-poll" at the end of the semester to the students in the honor's seminar course in which the data to develop it was taken. The results of the first eight questions based on the Drake equation were validated by comparison to data taken on students' values for each factor in their essays. The distributions of responses on the survey showed a high correlation to the distribution of the estimates for the Drake equation factor on which the question was based. For instance, the distribution of student response to the likelihood of communication with extraterrestrials (item 8) was similar to that of their distribution of final values for the number of communicating civilizations in the galaxy reported in their term papers, the final product, N, of the Drake equation. See Figure 2.

Items 1 and 9 are the only items in the survey that have "correct" answers. They are that the Milky Way Galaxy contains a few hundred billion stars and that radio signals would be the most likely way that communication with extraterrestrials would occur. The vast majority of students chose the correct answers on these items. Results for item 11 leaned more toward extraterrestrials we encounter being more technologically advanced. This suggests that students gained an appreciation of how difficult it would be to travel the immense distances between stars in our galaxy. Finally, in item 10, more students seemed to think aliens would be friendly than hostile, but most thought they would be unrecognizable.

4. RESULTS

The survey was given before and after instruction in the next offering of the honor's seminar on life in the universe and also in several sections of a nonmathematical, general education, introductory astronomy (*astronomy 101*) course in which life in the universe was covered as the last topic in only one or two class sessions at the end of the semester. In these sections, the Drake equation was introduced using the same, above-described, activity as it was in the honor's course.

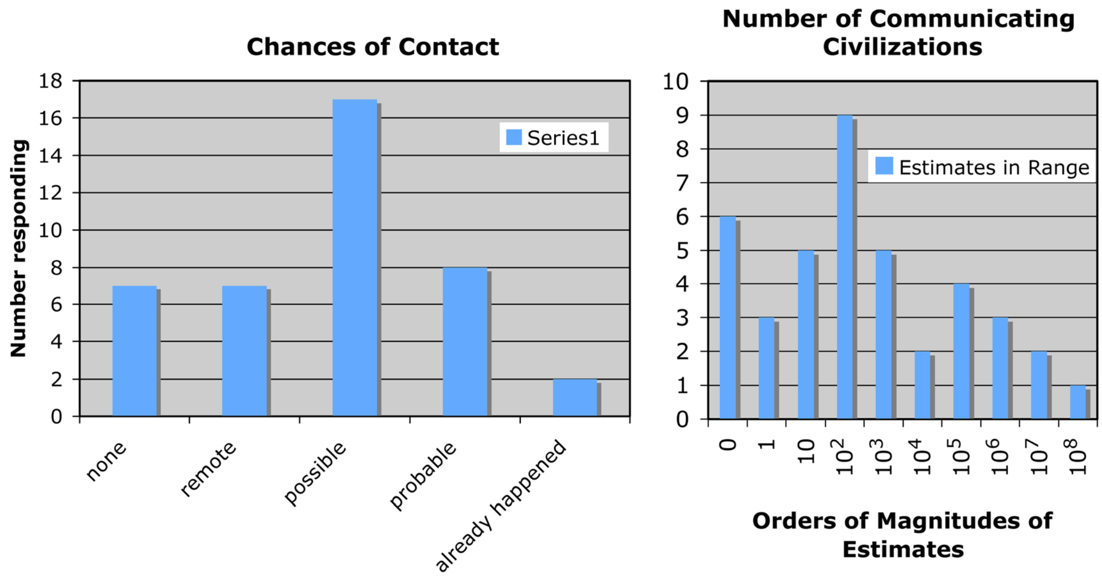


Figure 2. Histogram of responses to item 8 in the survey compared to the distribution of estimates of the final product "N" of the Drake equation from student term papers. The distributions are similar, with a peak in the middle and with lesser values on either side tailing off toward larger estimates

4.1 Seminar Course on Life in the Universe

The honor's seminar course on life in the universe, $N = 39$, showed change in the responses to most items after instruction. Item 1 (Figure 3) showed almost all students correctly identifying the estimated number of stars in the galaxy.

This was also true for item 9, the only other item in the survey that had a correct response. Over 90% of respondents selected the detection of radio signals as the most likely way to communicate with life elsewhere in the galaxy. Before instruction, over 50% had selected radio signals, but about 30% had selected robot spacecraft.

Item 2 (Figure 4) showed an overall increase in the estimates of the percentage of stars with planets. This was also true for item 3 (Figure 5) that also showed a large decrease in the number responding that there are very few habitable planets per system. This was likely due to the geology lecture in the above list of topics covered being largely about what factors contribute to a planet being habitable or "Earth-like."

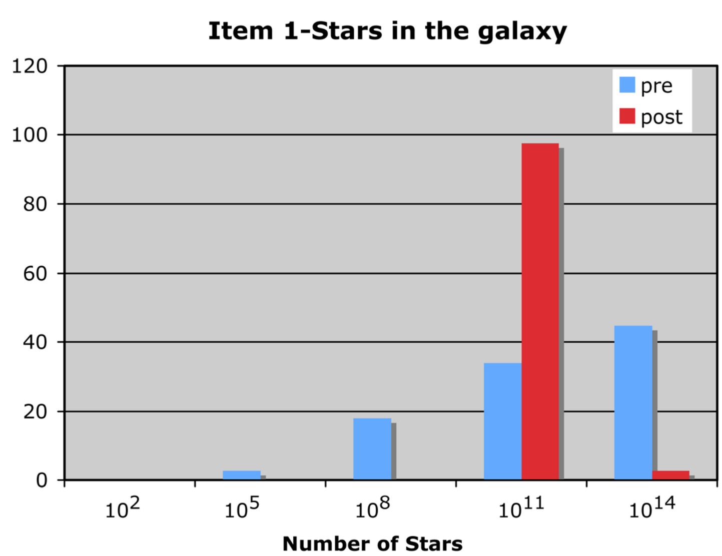


Figure 3. Almost all students in the honor's seminar course correctly identified the approximate number of stars in the galaxy after instruction

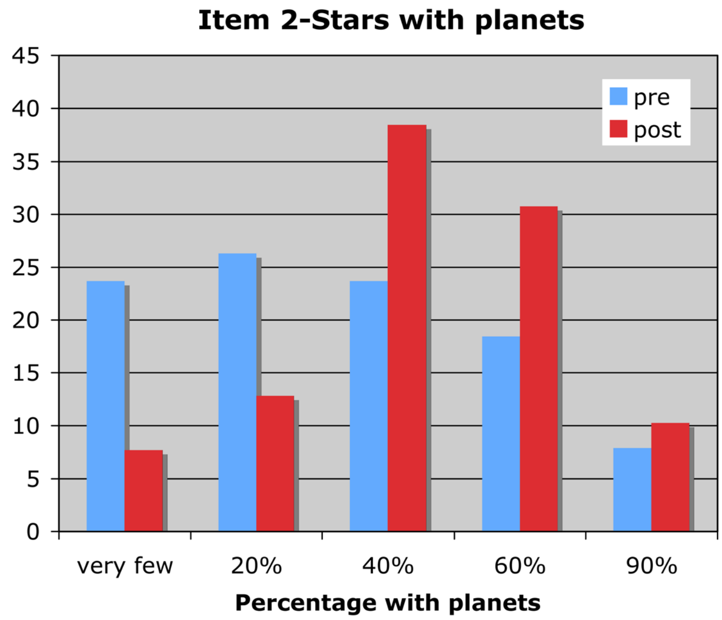


Figure 4. Estimates of the number of stars with planets increased after instruction

Items 4–6 showed increases in optimism about the chances of life originating, evolving to intelligence, and developing civilization on a habitable planet. Similar to the plot for item 5 (Figure 6), all three items began with approximately half of the respondents maintaining before instruction that there was little or no chance of any of these events occurring and becoming more optimistic after instruction. However, there was little consensus in *how* much more likely they estimated these events to be. This can be seen in Figure 6. Similar numbers of respondents selected each of the choices for item 5 on the posttest. As with item 3, these changes were likely due to the fact that there were lectures explicitly devoted to each topic; the origin and evolution of life, intelligence, and civilization and technology.

Item 7, the lifetime of technological civilization showed very little change in after instruction responses. The distribution was reminiscent of a bell-curve peaking with 35%–40% selecting 10 000 yr. There was a hint of

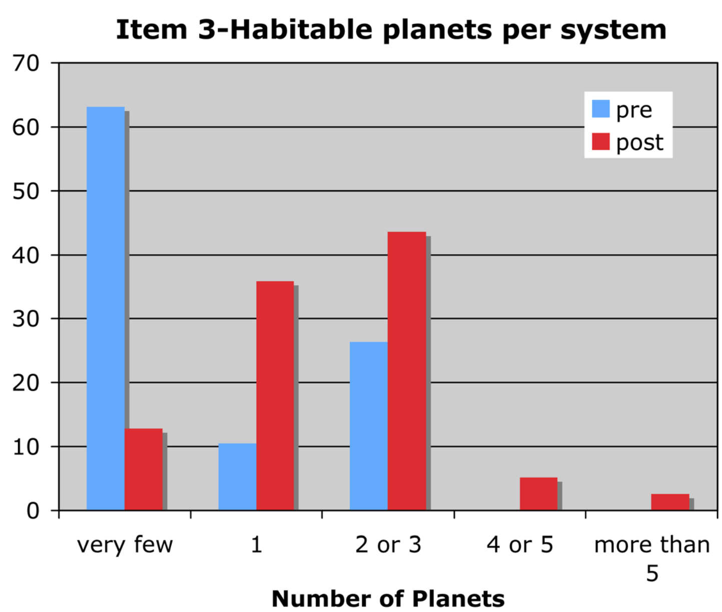


Figure 5. The majority estimated very few habitable planets per system before instruction, but estimates increased after instruction

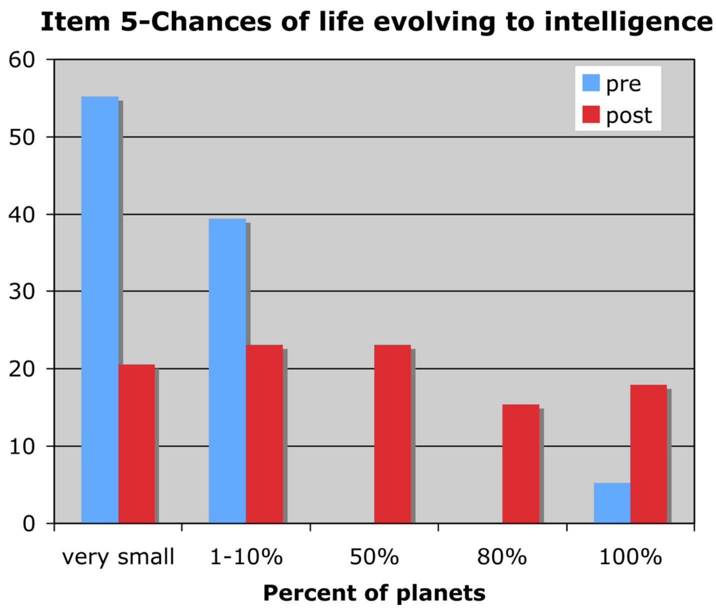


Figure 6. Estimates of the chances of the origin and evolution of life and development of civilization on a habitable planet were more optimistic after instruction (histograms for items 4 and 6 were similar to that for item 5)

pessimism, as 1000 yr was a more common response than 100 000 yr by a factor of about two, with about 30% and 15% choosing each, respectively.

Item 8, the chances that communication with extraterrestrial life could occur, reflects, N, the final product of all the Drake equation factors. Responses before and after instruction showed a slight shift toward pessimism. This is likely due to instruction resulting in an increased appreciation of the immense distances between the stars in our galaxy that results in planets in different systems being extremely isolated from one another. This fact was noted in many of the students' term papers in both semesters the course was offered.

It should also be noted that further validation of the survey comes from the distribution of the after instruction responses shown for item 8 (Figure 7). It was similar to that of the final estimates for N in student's term papers that same semester. This was also true of the responses to item 8 before instruction and the distribution of the student's initial estimates of N in the early semester activity in which they were introduced to the Drake equation.

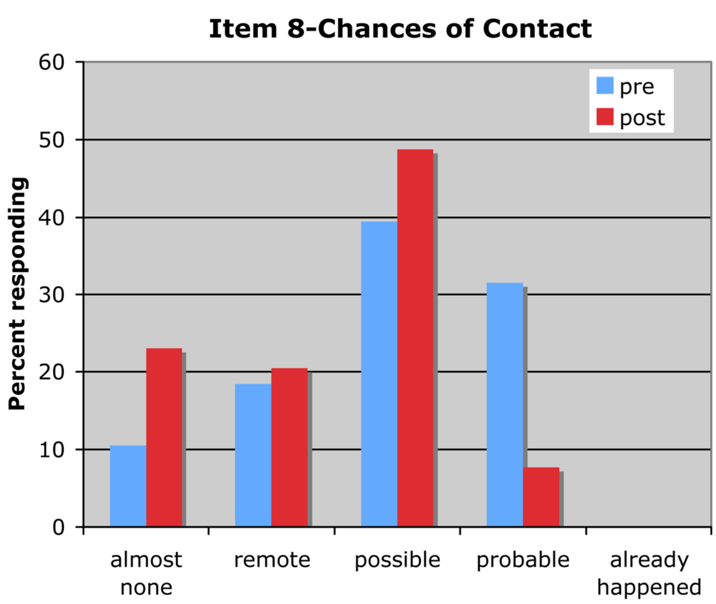


Figure 7. A small shift after instruction toward pessimism in the chance of communication

The fact that no students selected prior to, or after instruction, that communication has already occurred could be considered encouraging. This could be because members of a population of honor's students may be less likely to believe conspiracy theories about government cover-ups of such an event. As will be seen below, in the general education course, this was *not* the case.

Instruction showed very little effect on item 10 about whether extraterrestrials would be similar or different than humans and friendly or hostile. About equal numbers of respondents chose friendly and hostile before and after instruction and over 80% responded that extraterrestrials would be different than humans or unrecognizable. This was, again, before *and* after instruction.

Responses to item 11 comparing our technology to that of extraterrestrials that we may encounter largely favored their technology being superior to ours. The only noticeable change before and after instruction was an increase in the number of respondents that chose "much more advanced" and a decrease in those that chose "similar." This would once again likely be due to a gain in the appreciation of how remote stars and their planetary systems are from one another in the galaxy.

Response to item 12 about who should speak for Earth vastly favored scientists before, over 60%, and after, over 70%, instruction. This could be due to students telling the instructor what they think the instructor wants to hear. Only small percentages, 10% before and less after, responded that contact could be too dangerous.

4.2 Introductory Astronomy

Students in several sections of introductory astronomy taught by two different instructors over three semesters completed the survey at the beginning of the semester, N = 192, before any instruction and at the end of the semester, N = 150. Instruction included coverage of life in the universe in one or two class periods at the end of the semester. The same Drake equation activity done at the beginning of honor's seminar was part of the instruction.

As in the honor's course, the majority of respondents chose the correct answer for items 1 and 9 after instruction. Instruction resulted in very little change for items 2–7 all involving the factors of the Drake equation. This likely reflects the fact that the Drake equation activity was a topic on only one day of instruction rather than as much as an entire class meeting or more being devoted to single factor, as in the seminar course. As shown in the plot for item 5 (Figure 8), the responses before instruction were, in general, pessimistic. This was similar to those in the seminar. However, post instruction responses remained that way unlike those in the seminar that became more optimistic. The plot for item 2, the percentage of stars that have planets, showed not only very little change, but

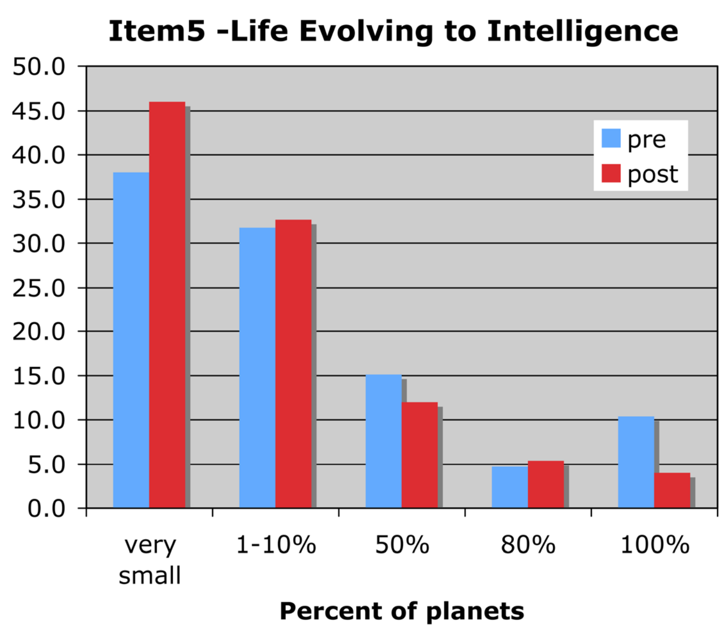
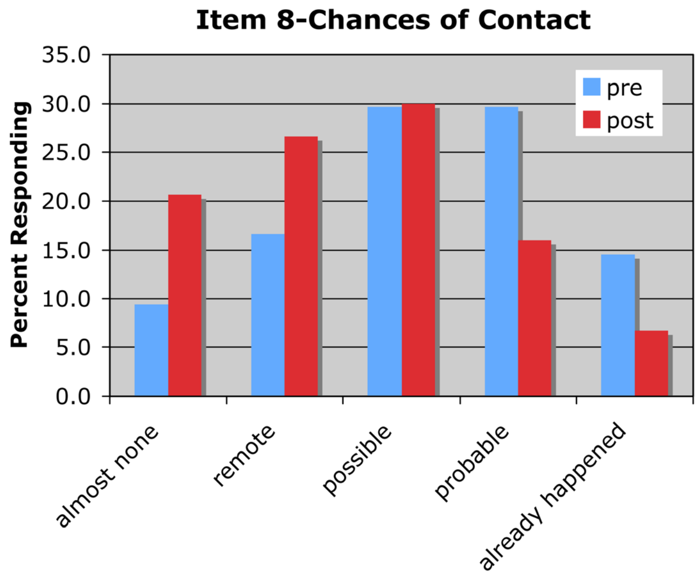


Figure 8. There was very little change before and after instruction in introductory astronomy in items pertaining to the Drake equation.



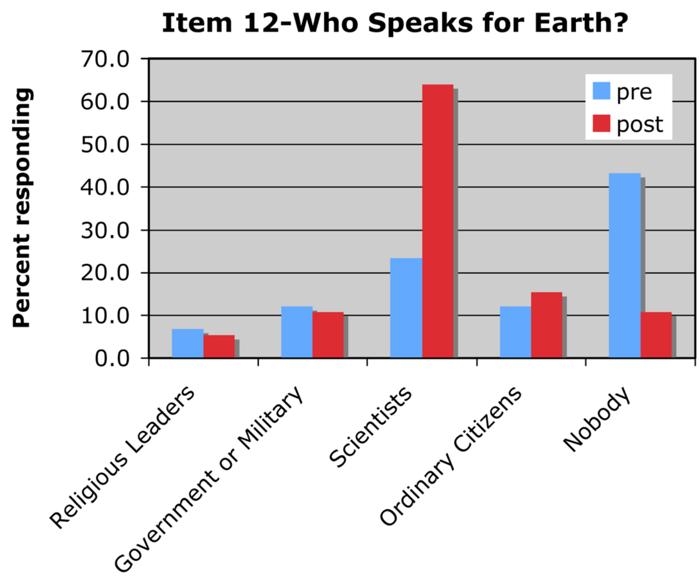


Figure 9. Instruction in introductory astronomy resulted in less students responding that contact already has happened in item 8 and that contact would be too dangerous in item 12. Also in item 12, instruction resulted in a large increase in students choosing scientists as the ones who should speak for Earth

also no consensus response. This suggests that the typical coverage of planets and stars as in separate "units" in an introductory astronomy class resulted in very little consideration of this question.

Responses for items 10 and 11 also showed very little change due to instruction, item 10 heavily favoring extraterrestrials being unrecognizable with similar numbers of respondents indicating that they would be friendly and unfriendly. Item 11 responses heavily favored extraterrestrials being more technologically advanced. This was also similar to responses in the honor's seminar.

Items 8 and 12 both showed interesting results in introductory astronomy that did not occur in the seminar course. In item 8, on the chances of contact, which is related to the final product of the Drake equation, N, nearly 15% of respondents indicated before instruction that they felt that contact had already occurred. This dropped by about a factor of two to fewer than 7% after instruction. In item 12, "Who speaks for Earth?," prior to instruction over 40% of respondents chose that contact was too dangerous and that nobody should communicate with extraterrestrials. This was exactly as predicted by the above-mentioned instructor of introductory astronomy. This dropped to just over 10% (by a factor of four) after instruction. The large increase in the percentage that selected scientists to speak for Earth also should be noted.

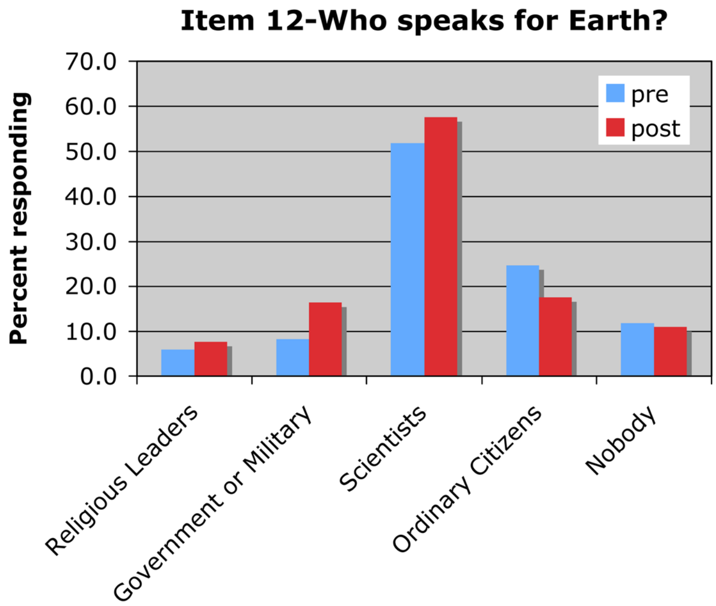


Figure 10. Comparison of this histogram with the item 12 histogram in Figure 9 shows that when the survey was given right before and right after coverage of life in the universe in introductory astronomy, the changes in the number of students selecting scientists to speak for Earth and that contact is too dangerous appears to have occurred prior to explicit instruction on life in the universe

During the first semester that the *Life in the Universe Survey* was used in introductory astronomy, the pretest was given toward the end of the semester, right before the actual instruction on life in the universe, instead of at the beginning as it was in subsequent semesters. This means that the students had experienced nearly an entire semester of introductory astronomy *before* taking the survey. The only major differences because of this were seen in responses to item 12. It can be seen in Fig. 10 that where the number of respondents choosing scientists as those who should speak for Earth was over 50% on the pretest, N = 85, and rose only to about 58% on the posttest, N = 92. Also, the percentage that felt contact would be too dangerous was just over 10% on the pretest and remained about the same on the posttest. When compared to the histogram for item 12 in Figure 9, this indicates that the significant changes in these responses seen in sections in the subsequent semesters, where the pretest was given before *any* instruction, may have occurred as a result of the earlier instruction in the introductory course *prior* to explicit instruction on life in the universe.

5. CONCLUSION

It is not surprising that the after instruction responses to survey questions relating to the factors of the Drake equation (items 1–8) by students from the honor's seminar were different than those of introductory astronomy students. The honor's students spent half of their semester studying the factors while introductory astronomy students were only exposed to the topic during one class period. It is, however, interesting that despite an entire semester of instruction on introductory astronomy, the students in the course showed very little change in their responses to these items. This suggests that the changes in response were due only to specific instruction on the Drake equation factors, like received in the honor's seminar, and that changes are unlikely to come about through general instruction on astronomy.

It could then be considered surprising that the postinstruction results for the more speculative questions about contact and the extraterrestrials themselves (items 9–12) were similar for both groups. This time it is *despite* the fact that the honors seminar spent the entire second half of their semester on the topics while the introductory astronomy students were only exposed to them over at most a day or two of instruction.

The most significant changes in the responses of introductory astronomy students, were on item 12, who should speak for Earth if contact is made. After instruction many more introductory astronomy students selected scientists as who should make contact with extraterrestrials, and many less students thought that contact should not occur because it would be too dangerous. As mentioned previously, these changes *do* seem to be a result of general instruction of astronomy because the semester that the pretest survey was given right before coverage of life in the universe and *after* everything else, a similar large number of students made these choices on both the pretest and posttest.

Perhaps the most concrete result shown by the survey is that students in the honor's seminar showed an increase in appreciation for how immense the distances between stars really are and how isolated we may very well be here on Earth and also that this would still be true even if the galaxy is teeming with life. As discussed above, this was a possible interpretation of several results of the survey. Most students come to introductory astronomy without the perspective of how much larger the distances between objects is than the sizes of the objects themselves (LoPresto, Murrell, and Kirchner 2010), so instilling an appreciation of this can be considered a positive result of instruction.

The number of students that came to introductory astronomy believing that contact with extra terrestrial life, something for which there is no actual physical evidence, had already occurred was alarming. The fact that instruction caused the number of students believing this to decrease can also be considered a positive result of instruction. It could also mean that the students of introductory astronomy also gained a similar appreciation to their honor's seminar counterparts on how isolated life in the galaxy may be.

A potentially interesting follow-up study would be to use the survey in a general education life in the universe or astrobiology course with a population of general education students (rather than honor's students only). Comparing the results both to students in the honor's seminar course and introductory astronomy could be informative.

Acknowledgments

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Note

Note 1: http://www.activemind.com/Mysterious/Topics/SETI/drake_equation.html.

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