# STUDENT QUESTIONING AND REFLECTION IN INTRODUCTORY ASTRONOMY

Students in an undergraduate, general education course in astronomy wrote questions they had at regular intervals of a semester. These written questions were then transcribed and coded in order to determine how students were thinking about the learning of astronomy, and what they viewed their learning goals to be. Our results suggest that learners must not only assimilate and accommodate information into their conceptual frameworks, but also intentionally reflect upon new information and how to conceptualize it.

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## Introduction

“Thinking” is a funny thing. We do it all the time, and yet not all of it is productive, not to mention rational. When we consider what it is that takes place in our classrooms, though, we *expect* that students should be thinking, but we may not always be so specific as to what we want this thinking to look like. As Dewey suggests, thinking may manifest itself in one of at least three different ways, but only one of these modes of thought is reflective (Dewey, 1910). As instructors, we want our students to not simply “think,” but to think actively and reflectively.

On the other hand, while we may have an idea about what reflective thinking could look like, it is more difficult to imagine how to encourage such reflective thinking. If we had a more specific set of concrete examples as to what reflective thinking looks like and what habits facilitate this thinking, perhaps we could better explain to students what our view of “learning” looks like. Moreover, we could have a better idea for ourselves, as researchers, as to what kind of thinking we could identify as being either particularly reflective and/or useful in the process of learning specific concepts.

In order to help us understand how students conceptualize and conduct their own learning in an introductory college science setting, we formulated this pilot study. Our basic rationale was that we wanted to get a glimpse into what our students were thinking about in the context of a university general education science course. At the same time, revealing students’ thinking in the context of a course could be difficult for students and difficult methodologically. Our simplistic solution was to ask students to pose questions, in written form, about which they were thinking. These data gave us a starting point to begin analyzing at least some aspects of what these students were thinking about.

## Theoretical Underpinnings:

The learning process has been characterized in many different ways. In science education, we espouse and emphasize constructivism (e.g., Driver et al., 1994) as an





epistemological foundation for student learning. Upon this foundation we often highlight the conceptual change process (Posner, Strike, Hewson, & Gertzog, 1982) as a way to characterize specific learning instances. Learning, in this light, can take place when new information is carefully and accurately integrated into existing knowledge (assimilation), or when old knowledge is restructured and replaced with new conceptions (accommodation). To be sure, many have gone to great lengths to describe the variety of details involved in this latter process (e.g., Chi, 1992; Demastes-Southerland, Good, & Peebles, 1996; diSessa, 1993; Vosniadou, 1994).

Students, however, may not always see the accommodation process as productive or even necessary. Learning science content that is altogether new to them may not be viewed as contradicting their preconceived notions, so conceptual change is not an obvious route to learning. On the other hand, simple assimilation of information is too gruesome a task when one is faced with novel ideas that have little to do with everyday experience (e.g., astronomy). In this case, some mediating process of reflection must take place in order to allow students to understand scientific concepts.

Our study is an attempt to look at how students see the learning process itself. We imagine that at the same time that learning itself has many different possible accretions, leaps, or revolutions, learners may be better off in these processes if they could consider what kind of learning, and thus thinking, was necessary in specific situations. Seeking to understand what science learners at the undergraduate level explicitly think about should help us to sort through how learning most effectively takes place.

## Design and Procedure:

Students (n=18) in an undergraduate general education astronomy course were asked to periodically write down a question that they had at that moment regarding the course. These took place in formal class assignments, either at the end of a class session as an independent assignment, or at the beginning of class as an addition to a regular class quiz. Overall, these questions were collected at 10 different times during the semester and transcribed by the instructor (first author). Exam scores and course grades were also recorded for each student.

At the end of the course, transcripts of all students’ questions were used in order to code questions into categories. Utilizing grounded theory (Strauss & Corbin, 1998), the data were analyzed three times in succession in order to determine the categorizations and how each question would be coded. The first analysis of the data allowed the researchers to elicit possible categorizations. In the second analysis of the data specific questions were sorted into these categories. Finally, a third run through the data allowed the researchers to look for questions that did not fit into the presupposed categories and also to eliminate categories that were redundant. The final categorizations are reported below.

After these categorizations took place, we could consider how varied the categorizations were between students, and whether or not they seemed to correlate with course performance. However, with such a small sample size, and considering that we saw this as an idea-generating stage of our research, we do not claim to come to any grand conclusions from our data. We simply hope that these initial findings give us ideas as to how to proceed from here.

**Findings:**

As described above, several primary categories of questions were illuminated:

*Type I: Course logistics and miscellany* (14%)
Characteristic examples:

- Are the new chairs going to be adjustable so we can sit up for lecture & note taking & recline for star observation?
- How far in the book do you plan to cover?
- Can we have drinks in class?

These types of questions were in many senses very important to students, and often they highlighted simple course issues that needed to be addressed. As a result, these issues would often be responded to in subsequent class meetings. They did not, however, directly relate to the course curriculum or to students' understandings of astronomy.

*Type II: Informational ("tourist")* (35%)
Characteristic examples:

- Are the moons on Jupiter larger or smaller than our Moon?
- Are there any telescopes, really big ones, in Utah?
- Do other planets have an axis tilt like the earth does?

These questions sprout up mostly independent of what a student already knows and independent of what the instructor viewed as goals for learning. These questions may be interesting, especially to the student asking them, but they do little to build new knowledge relevant to the course, or to produce extensions from the course to the student's own life. Rather, they seem to be loosely associated with content from the course, but are not being asked in order to advance a student's understanding. We thought of these as "tourist" questions, as they may have been the kinds of things that would be asked about by someone being guided about an exhibit or natural attraction – they emerged for the learner, but in a spontaneous manner rather than in a way that tied their thinking to the thread of knowledge in the curriculum.

*Type III: "How to" questions (5%)*
Characteristic examples:

- How do you determine the time each phase of the moon is going to rise & set?
- How do you know what kind of binoculars to buy? What optics do you want?
- I would like to see what the night sky looked like at the time of my birth [time/date given]

Students would sometimes offer questions regarding how to view something, how an assignment should be completed, or about how to conduct a specific aspect of a project. These types of questions may be tied to the curriculum, but only in a procedural manner. In other cases, students simply wanted some information for their own personal use.





*Type IV: Conceptual* (22%)
Characteristic examples:

- Are all galaxies pulling away from our own and why is that we cannot tell where they are being pulled to? Are we moving and if we are moving is there a galaxy that we are getting closer to?
- Since we are on a plane in our solar system and in our galaxy, is that also how the universe is set up? Or is there no specific organization?
- What is the difference in Nova and Supernova?

These questions tended to mesh with the goals of the class more than any of the above question types. Such questions attempted to see how ideas in the course connect, or how certain phenomena relate to one another. The potential answers to these questions were explanations of how nature works. Often, these would be linked to specific class topics from that day's (or the previous day's) activities, but this was not necessarily the case.

*Type V: Epistemological* (9%)
Characteristic examples:

- How do we know that black holes are sucking things in? Is it just because we know light cannot escape them?
- If Pluto is hard to see, how do we <u>know</u> there are other solar systems upon other galaxies inside the universe? The theory makes sense, but <u>how do we know</u> for sure?
- How do they know the distance to a star/planet, because they wouldn't be able to figure it out by sending radar and getting information back by the [reflected] radar.

For an instructor who emphasizes aspects of "how do we know" and the nature of scientific knowledge, these are often some of the most exciting questions we can get. Learners were trying to understand where scientific claims (usually presented in a recent class activity) were coming from, and specifically how the empirical data supported certain claims. These questions poked at how the methodology of astronomy and science in general works. As astronomy is unique in its scale (both in time and space) as a science, it may be that these types of questions came up more in an astronomy course than they would in other general education science courses.

*Type VI: Reflective* (15%)
Characteristic examples:

- I'm still confused on how they can tell how far away a planet or star is, but I know we just might not have reached that section yet, so I can be patient.
- What is the solar cycle? The text says it takes 22 years to complete something. I thought it's talking about sun spots' emerge & disappear cycle, but I'm confused.

For us as researchers, these questions stood out because they were prefaced or otherwise highlighted by an admittance on the student's part that he was not fully understanding something. Or, in some cases the students would compare what they understood in one context (e.g., via reading the text) to how they understood something in another context (e.g., the instructor's explanation). For us, this was characterized as "reflective" because it contrasted the learner's understanding with something else. This feedback loop of sorts was interesting to us and frequent enough in the data that we separated it from other similarly conceptual questions.

These question types were used in varying degrees by different students. To demonstrate this, we quantified the number of times each student asked a different kind of question that was related to the curriculum of the course. These are shown in figure 1, simply to point out how different each learner was in his or her questioning.

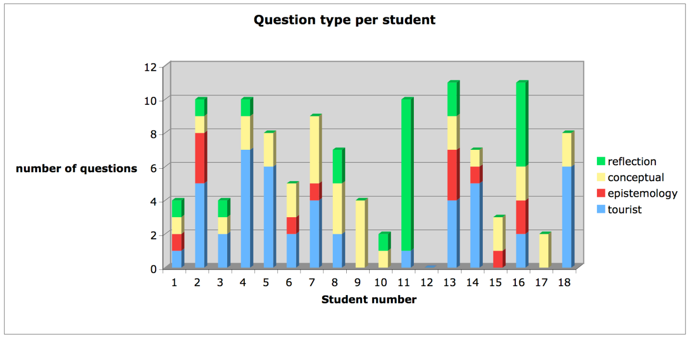


Figure 1

In the subsequent figures, we try to demonstrate a very rough set of correlations between course performance and the frequency of question being asked. For the sake of comparison, we show a sum of exam scores versus frequencies of "tourist," "conceptual," and "reflective" questions in figures 2, 3, and 4, respectively.





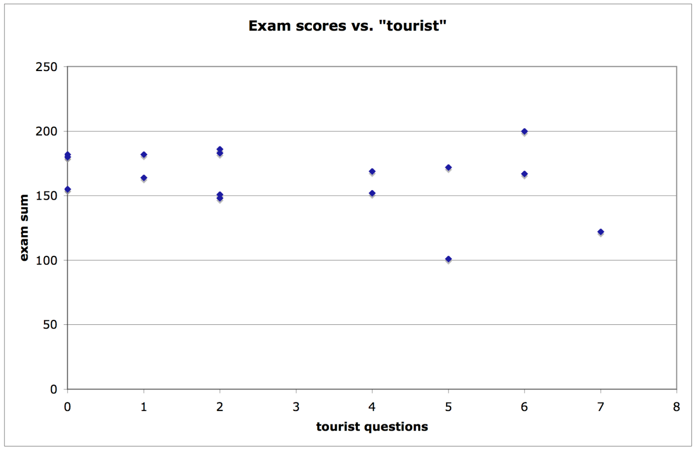


Figure 2

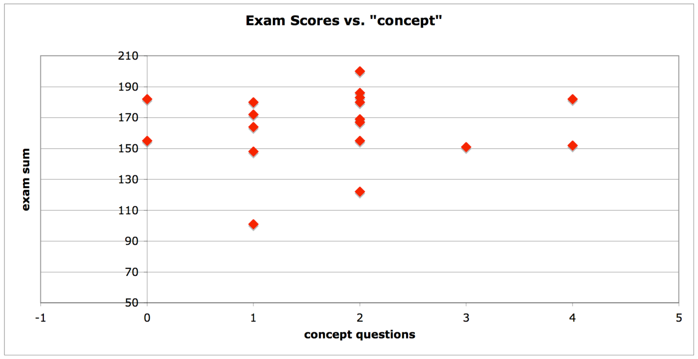


Figure 3

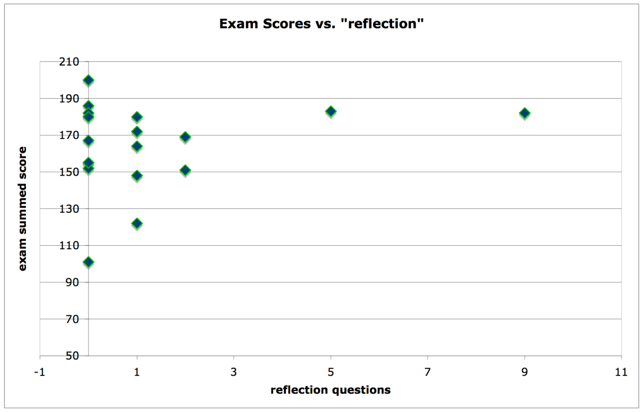


Figure 4

**Discussion:**

With the small number of students, all participating in only one course, it would not be wise to jump to a generalization of the results. However, there are a few interesting points that are of interest to us. These will shape our future research.

First, it is remarkable to us just how varied the percentages of each question type is for each student (Figure 1). Although we have always known that each individual is unique, it is fun to see this manifest itself in the kinds of questions being asked. Is this a result of personal interest, attention, thinking, etc.? We would like to pursue this in future work.

Second, about half of all of the questions being asked by students were directly related to the course curriculum. As stated above, these questions were often necessary (especially from the students' points of view). It would be interesting to see if there were ways to take care of these issues in some other way if student questions would become more focused on the focus of the course. Or, if less attention were paid to these kinds of questions, would students begin to concentrate more intently on specific learning goals?

Finally, we are especially interested in the issue of reflective questioning. Certainly, our data do to say, "If you ask reflective questions you will do better in the course," but it's clear that in this particular course that students engaging in this kind of thinking and question did do better on exams. It should be noted that, while in many cases the students' questions were explicitly addressed in subsequent classes, there was no major effort made to answer all students' questions, as this was simply impossible. So, those who were asking the "reflective" questions were not necessarily getting them answered by the course instructor.





For us, focusing on the questions of students allows us to consider how they are thinking about the learning process. Our results are in line with others who suggest that the learning process must be driven and directed in a deliberate fashion (Sinatra & Pintrich, 2003). On the other hand, others have shown that students exhibit a certain savvy when it comes to succeeding in school, so that they can identify and distinguish between what they should do to "learn" and what they should do to succeed in a scholastic environment (Elby, 1999). Although much of educational research points to what looks like successful learning, it is quite another thing to get a student to understand and practice learning in a manner that is compatible with an instructor's goals. We look forward to continuing this line of questions, ourselves, and we welcome others' efforts and suggestions.

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