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## "Hot Seat" Questioning: A Technique to Promote and Evaluate Student Dialogue

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### Abstract

Several approaches have been proposed to include students in classroom dialogue, including "think-pair-share" and "talk to your neighbor." I recently implemented an additional technique in which four students answer questions in a "Hot Seat" at the front of the classroom. An unforeseen by-product of this was student-initiated peer instruction outside of the classroom. A small case study (approximately 50 students) on the effect of the Hot Seat using the midterm exam showed that students were  $9.5 \pm 3.2\%$  more likely to correctly answer a question related to material covered while they occupied the Hot Seat. Analysis of the Astronomy Diagnostic Test revealed that they were twice as likely to learn their Hot Seat material. A survey revealed one likely reason: Students typically spent 15-60 additional minutes preparing for class on their two assigned Hot Seat dates. Curiously, students received no significant benefit ( $2.2 \pm 3.6\%$ ) from their second turn in the Hot Seat, possibly reflecting student immunization to its motivational pressure.

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Discussions in the astronomy classroom, like those in other fields, can often be dominated by the instructor and a handful of students. Several approaches have been proposed to include all students in the dialogue, including "think-pair-share" and "talk to your neighbor." In addition to these techniques, I recently implemented a policy in which student groups of four answer questions in a "Hot Seat" at the front of the classroom. Each group was assigned two dates during the semester on which questions typically addressed to the class as a whole were instead directed to the group. This portion of the course counted as 5% of their final class grade. An unforeseen by-product of this practice was student-initiated review sessions, leading me to conduct a small case study ( $N_{\text{students}} \approx 50$ ) on the effect of the Hot Seat. Analysis of the midterm exam showed that students were  $9.5 \pm 3.2\%$  more likely to correctly answer a question if it was related to the material covered while they were in the Hot Seat. A similar analysis of the Astronomy Diagnostic Test revealed that students were twice as likely to learn material that they covered

in the Hot Seat. One likely reason reported by students in response to a survey is that they typically spent an additional 15-60 minutes preparing for class on their two assigned dates. Curiously, no significant improvement ( $2.2 \pm 3.6\%$ ) existed for material covered during each group's second turn in the Hot Seat, as gauged by the final exam, possibly reflecting student immunization to the fear factor of the Hot Seat.

## 1. INTRODUCTION

Introductory astronomy courses often encourage attendance by rewarding students with points for participation. The definition of participation can vary from mere attendance to completion of graded in-class projects. During the spring 2003 and fall 2003 semesters, my Introduction to Astronomy class featured a system in which all students were given points for attendance (5% of final grade), and individual students were rewarded daily for answering a difficult question, asking an intelligent question, or volunteering to assist with a demonstration. However, this policy ultimately led to class time being dominated by a handful of students and myself (as instructors tend to do; Singham 2004). In two sections with 30 students each, the five most vocal students earned over a third ( $33.4 \pm 2.0\%$ ) of the discussion points. In contrast, the shyest 18 students in each class received almost the same fraction of points ( $34.6 \pm 1.4\%$ ). At the end of the semester, students reported that this was an unpopular means by which to encourage participation. As instructor, I also felt that this approach needed revision. In redesigning my class participation scheme, I needed one that would

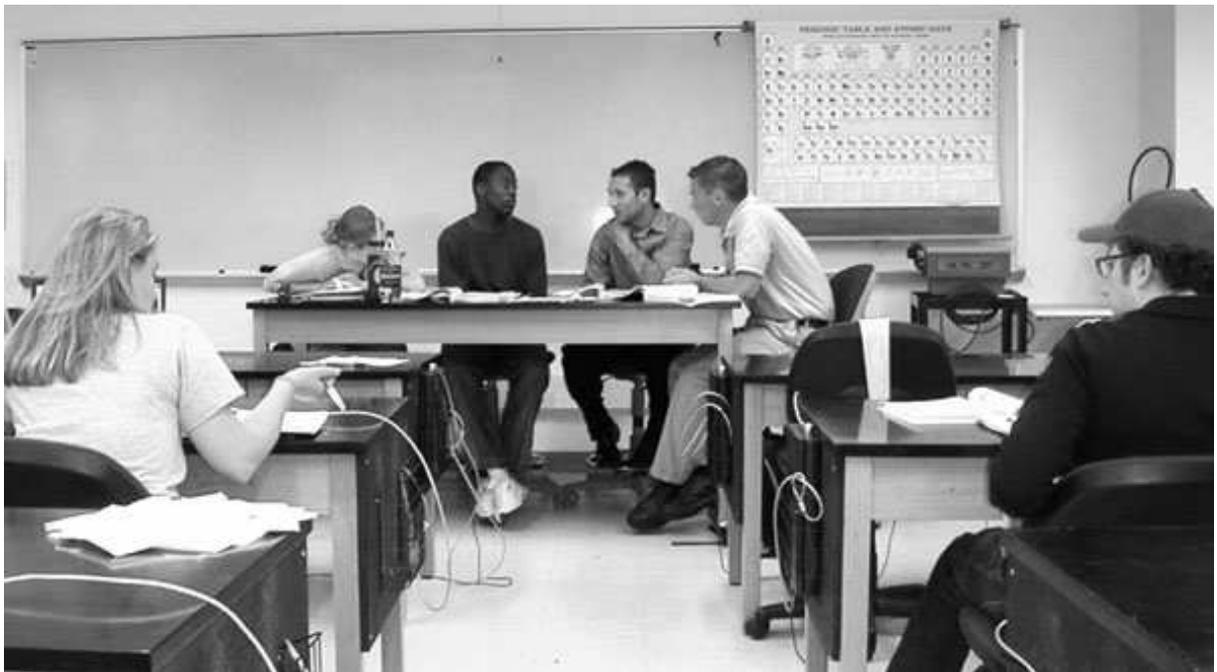
- a) encourage all students to engage in the classroom discussion,
- b) reward students with points for meaningful participation, and
- c) not involve extra instructor effort.

Approaches that address the first of these criteria include "think-pair-share" (Lyman 1981) and "talk to your neighbor" (Slater & Adams 2003). Although I have employed these techniques in my astronomy classes, they do not meet the second criterion listed above, namely providing a simple mechanism for gradable evaluation. Although personal response systems, or "clickers," would allow for classwide gradable participation, we do not currently have such a system in my department. In spring 2004, I developed a new practice, the Hot Seat, that would address each of the items listed above.

## 2. ASTRONOMY IN THE HOT SEAT

The Hot Seat concept is very simple. Students were randomly sorted into groups of four on the first day of class. Because I was already doing this to enable small-group discussions, it posed no extra effort on my part. Each group was then given two dates during the semester when the students would sit at the front of the room facing the class and answer questions related to the day's material (Figure 1).

Students received points based on the fraction of questions that their groups answered correctly. Although the audience was encouraged to direct questions to students in the Hot Seat, as instructor, I posed nearly all questions. The majority were general questions that would normally be addressed to the class as a whole. Many involved interpretation of slides or recollection of key concepts from the text. Students answered 90% (5% standard deviation) of the questions correctly.



**Figure 1.** A group of four students sitting in the Hot Seat at the front of the classroom. In the front left corner of the room is a screen for displaying lecture slides. On the left wall is a second whiteboard for use by the instructor.

### **3. STUDENT IMPRESSIONS OF THE HOT SEAT**

My implementation of Hot Seat questioning was in direct response to student feedback on a prior participation system in which individual students received points for asking or answering questions in class. In open-ended student evaluations from fall 2003, 9 out of 22 students commented that this was an area for improvement, and none noted it as helpful. To gauge student opinion of the Hot Seat experience, I administered both a multiple-choice survey asking questions about specific aspects of the course, and the university's official open-ended student evaluation form.

In the multiple-choice survey, students were asked which component of the class was most helpful in learning the material. Of the 50 students responding, many cited listening to the instructor (17 students), taking online prequizzes (16 students), or seeing PowerPoint presentations (13 students) as helpful. Only three students marked that preparing for the Hot Seat was most helpful. Clearly, the students felt that this was not the dominant mechanism in their learning of astronomy. However, in the open-ended student evaluations, 10 out of 46 remarked that being in the Hot Seat was helpful. This was an obvious turnaround from the previous semester, when as many students had deemed class participation to be in need of revision.

Only three students responded negatively to the Hot Seat. One wrote, "I didn't like how the Hot Seat was put on the spot in front of the class." Another said, "The Hot Seat stuff eliminates the rest of the class from participating daily." The third simply jotted, "No more Hot Seat; it doesn't help." The first comment shows that some students can be sensitive to being "put on the spot," even when it is with three other classmates in a scheduled event. The second comment was a concern I shared before the class began. Surprisingly, I found the opposite to be true. The remainder of the class was *more* vocal when asked to respond to questions that the Hot Seat missed than they were during standard lectures. This tone was similar to that of a game show, with the "audience members" sometimes shouting out answers before the Hot Seat "contestants" could respond. The third comment that it doesn't help is one that also appears false when we examine the test scores related to Hot Seat questions, as we do below.

#### **4. EFFECTIVENESS OF THE HOT SEAT**

As stated above, the primary intent of the Hot Seat was to provide an opportunity for all students to earn points for meaningful class participation. Throughout the semester, I noticed a surprising new phenomenon at the end of class: Student groups were planning review sessions to prepare for their days in the Hot Seat! I was curious how this preparation before class would affect student learning. My investigation was guided by several questions listed as section headings below.

To gauge effectiveness at improving subject mastery, I analyzed responses on both the midterm and final exams. During the 2002-2003 and 2003-2004 academic years, instructors at Elon University have used *Universe: The Solar System* (first edition) by Freedman & Kaufmann. The accompanying *Test Bank for Universe Sixth Edition* by Clark & Wilson (2002) was the source of nearly all of the midterm and final exam questions.

As another measure of student learning, I administered the Astronomy Diagnostic Test (ADT) Version 2.0 (Hufnagel 2002) at the beginning and end of the course. This commonly used conceptual exam is a descendant of the Project STAR Astronomy Concept Inventory (Sadler 1998) and the Misconceptions Measure (Zeilik, Schau, & Mattern 1998; see Bailey 2003 for a full history). The ADT covers a range of basic astronomical topics, including diurnal motion, lunar phases, and global warming. Deming (2002) has demonstrated both the reliability and validity of this test in a nationwide sample of 5,346 precourse scores and 3,842 postcourse scores.

Of the 21 astronomy questions on the ADT, only questions 2, 5, 6, 8, 14, 18, and 21 concerned material covered on a day in which students were in the Hot Seat. In Table 1, I summarize the relevant parameters for all three exams (i.e., midterm, final, and ADT), including the number of students, the total number of questions, and the number of questions related to material covered by a group in the Hot Seat.

**Table 1.** Characteristics of exams used to gauge effectiveness of Hot Seat questioning. Parameters listed include the number of students taking each exam, the number of questions on each exam, the number of questions related to material covered by a group in the Hot Seat, and the total number of student responses to the questions related to material covered by a group in the Hot Seat.

	<b>Midterm</b>	<b>Final</b>	<b>ADT</b>
Students ( $N_S$ )	55	52	48*
Questions ( $N_Q$ )	50	100	21
Hot Seat Questions ( $N_H$ )	36	49	7
Hot Seat Responses ( $N_S \times N_H$ )	1,980	2,548	336

\*Only students taking both the precourse and postcourse ADT were included in this study to minimize uncertainty in the gain.

#### **4.1. Is a Student More Likely to Learn Material that He or She Is Expected to Discuss in the Hot Seat?**

This first question is the most obvious one. In Table 2, I list the percentage of correct responses in the following two subsets: (1) responses by students to questions related to their Hot Seat material, and (2) responses by the remaining students to these same questions. There is a significant difference between these two populations. Combining the midterm and final exams, there is only a 0.04% probability that the improved performance is by chance. Curiously, most of this significance is based in the midterm ( $t = 3.0$ ,  $p = 0.15\%$ ). The final exam results are improved for the Hot Seat students, but are nevertheless consistent with no gain ( $t = 0.47$ ,  $p = 32\%$ ).

**Table 2.** Responses to midterm and final exam questions related to material covered in the Hot Seat. The upper table summarizes the responses by students to questions related to their own Hot Seat material. The lower table displays the responses by the remaining students to the same subset of Hot Seat questions. Although there is a 3.0-sigma difference between the two groups' midterm exam responses, there is a difference of only a 0.5 sigma for the final exam.

<b>Hot Seat Students for Related Material</b>				
	N students	N questions	N responses	% correct
Midterm	55	36	273	73.6 ±2.7
Final Exam	52	49	359	74.4 ±2.3
Combined	--	85	632	<b>74.1 ±1.7</b>
<b>Remaining Students for Same Material</b>				
	N students	N questions	N responses	% correct
Midterm	55	36	1,707	64.1 ±1.2
Final Exam	52	49	2,189	72.2 ±1.4
Combined	--	85	3,896	<b>67.8 ±0.7</b>

As a second test of the effectiveness of the Hot Seat, I performed a similar analysis using the ADT. Here I compared gains by students on questions related to their Hot Seat topic ( $g = 0.33$ ) with the gains by the remaining students answering these same seven questions ( $g = 0.16$ ). The results for each question appear in Table 3. Although the gain of the Hot Seat students is higher, with so few questions, the difference is moderately significant: only 1.7 sigma, with a chance probability of 5.0%.

**Table 3.** Responses to the seven Astronomy Diagnostic Test questions related to material covered in the Hot Seat. The upper table summarizes the responses by students to questions related to their own Hot Seat material. The lower table displays the responses by the remaining students to the same subset of Hot Seat questions. The gain on these questions of the former group is nearly double that of the latter, with a 5% chance that this difference is by chance.

<b>Hot Seat Students for Related Material</b>				
Question	Student ( $N_S$ )	Pretest	Posttest	Gain

2	7	0.29	0.43	0.20 ±0.22
5	7	0.00	0.29	0.29 ±0.18
6	5	0.00	0.00	0.00 ±0.00
8	6	0.17	0.67	0.60 ±0.30
14	5	0.00	0.20	0.20 ±0.20
18	7	0.14	0.71	0.67 ±0.21
21	7	0.14	0.43	0.33 ±0.29
<b>Combined</b>	44	0.11	0.41	<b>0.333 ±0.087</b>
<b>Remaining Students for Same Material</b>				
Question	Student (N <sub>S</sub> )	Pretest	Posttest	Gain
2	41	0.20	0.34	0.18 ±0.12
5	41	0.10	0.22	0.14 ±0.09
6	43	0.00	0.09	0.09 ±0.04
8	42	0.19	0.43	0.29 ±0.11
14	43	0.16	0.14	-0.03 ±0.09
18	41	0.39	0.49	0.16 ±0.17
21	41	0.12	0.39	0.31 ±0.10
<b>Combined</b>	292	0.16	0.30	<b>0.160 ±0.039</b>

#### **4.2. Does the Class as a Whole Do Better if Someone Is in the Hot Seat, or Do Students Do Better Without It?**

Although it would be interesting to see if students not in the Hot Seat benefited (or suffered) from other students being in the Hot Seat, there is little reason to expect this. To examine this issue, I used the seven ADT questions related to Hot Seat material. The gains on these questions by students sitting in the Hot

Seat audience ( $19.7 \pm 2.8\%$ ) were not significantly different from those of previous semesters ( $18.8 \pm 3.8\%$  in spring 2003, and  $22.7 \pm 5.3\%$  in fall 2003). I conclude that there is no evidence that the Hot Seat system detracted from the learning experience of students not participating in it on a given day.

### **4.3. Are the Hot Seat Students Intrinsically Smarter, Leading to a Bias?**

On both the midterm and final exams, nearly all of the students were included in both the Hot Seat population and the audience population, depending on the question. However, in analysis of the ADT, only seven Hot Seat-related questions corresponding to five groups were used in the test sample. It is not unreasonable that these students could, by chance, be intrinsically brighter. To test this, I compared their performance with that of the remaining students on the 14 ADT questions unrelated to any Hot Seat material. The Hot Seat population scored lower, though this difference was insignificant ( $12.4 \pm 5.0\%$  vs.  $18.3 \pm 1.8\%$ ).

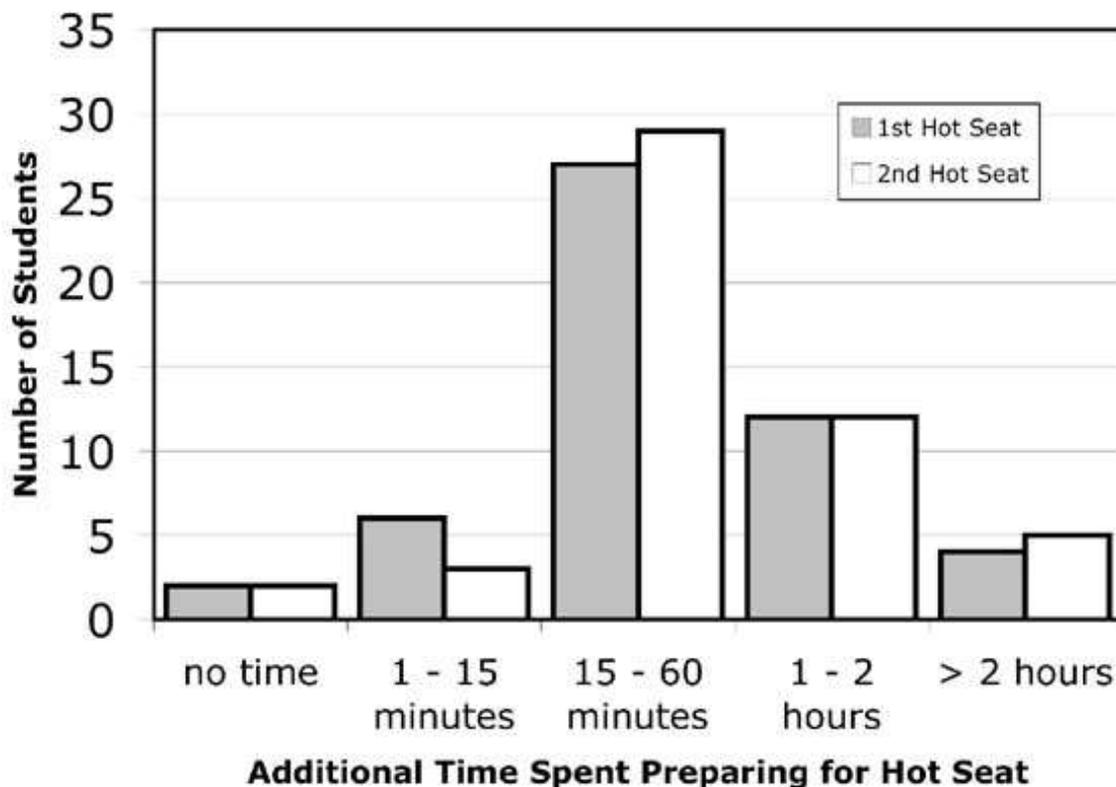
### **4.4. Were the Exam Questions Valid?**

The midterm exam questions had an average difficulty of 0.69 and discrimination of 0.37. The final exam questions had an average difficulty of 0.71 and discrimination of 0.36. Although these average values are acceptable, they indicate that a nonnegligible fraction of items might not discriminate effectively.

## **5. DISCUSSION**

Based on this preliminary study, the Hot Seat system appears to aid students in learning their assigned topics. There is a significant improvement of 10% on the midterm exam questions related to each student's Hot Seat material. Additionally, a student is twice as likely to learn an ADT concept if it is covered while he or she is in the Hot Seat.

What led to this improvement? In response to a survey, students reported spending approximately 20 extra minutes preparing for their *first* turn in the Hot Seat (see Figure 2). This was also true when asked about the *second* turn in the Hot Seat, with three students changing their replies from "1-15 minutes" to "15-60 minutes" (2 students) or "> 2 hours" (1 student).



**Figure 2.** Results of survey questions asking students, "How much extra time did you spend preparing for your *first* turn in the Hot Seat?" and "How much extra time did you spend preparing for your *second* turn in the Hot Seat?" There was no significant difference between the two distributions.

Unfortunately, little is known about how students spent this additional time preparing for class. Often, I noticed students making plans with their groups to prepare for the Hot Seat. It is possible that the significant results of the midterm and ADT stemmed from additional peer instruction occurring *outside the classroom*. That each Hot Seat group received a single grade may have provided the stimulus for these extra meetings. The concept of a group grade is not new, but its effect on student learning is only now coming to light. One tantalizing result on the topic was reported by Byrd, Coleman, & Werneth (2004). When assigning collaborative quizzes to Astronomy 101 students, they noted an improvement from 57% to 80% on a noncooperative final exam after having implemented a policy of daily group quizzing. Unfortunately, their control group (with 57%) involved no daily quizzing, so one cannot resolve the effect of having daily quizzes from the effect of group quizzes.

In light of the Hot Seat's strong correlation with midterm and ADT performance, it is curious that the effect on the final exam was so marginal. I suggest two possible explanations:

- a) Students studied harder for the final exam, diluting the effect of the Hot Seat.
- b) Students studied harder for the first Hot Seat, giving it more impact.

On the same end-of-semester in-class survey mentioned above, 80% of the students reported that they spent more than two hours preparing for the final exam. In a separate online survey given less than a week before the midterm, 89% of the students reported that they planned to spend more than two hours preparing for that exam. Because the two questions are different, it is difficult to directly compare these two values. At best, we can say that students planned to study more for the midterm exam than they actually did for the final exam. Although we cannot eliminate the first hypothesis, we also do not have direct evidence in favor of it.

The second hypothesis suggests that after being in the Hot Seat, students became "immunized" to it and did not feel the pressure to study as intently. If this were true, then a class with multiple types of assessment used only once would lead to the most learning. However, as noted above, students reported studying almost equally for both turns in the Hot Seat. One would need more detailed survey questions to compare the degrees of preparation for each day in the Hot Seat.

Ultimately, the Hot Seat led to only a slight increase in learning when considering all students' responses to all questions. Its key strength is that it involves almost no extra preparation on the part of an instructor who already creates groups for collaborative learning exercises such as "think-pair-share" or "talk to your neighbor." Indeed, the Hot Seat questioning is meant to complement rather than replace these other techniques. A practice that may optimize the value of the Hot Seat in the future is to assign topics to groups based on deficiencies gleaned from the ADT pretests.

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