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In the Classroom

An Exciting Approach to Student Learning in Analytical Chemistry: It's Jeopardy!

PATRICIA ANN MABROUK
Department of Chemistry
Northeastern University
Boston, MA 02115
pmabrouk@lynx.neu.edu

Playing the Jeopardy game allows students to help themselves and each other, while enjoying their study time in the process.

The television game show Jeopardy has been adapted for use in teaching students Quantitative Analysis. The exercise shows students how to study, encourages the development of good team-working skills, and presents the study of analytical chemistry in a fun and exciting way. One unique aspect of in this approach involves the use of data from the primary analytical literature as the basis for one category of problems called "Real World." These questions help students see the significance and relevance of the material presented in the course for solving real-world problems and in their future careers. The approach can be used effectively in both large and small classrooms and can be adapted for use in other undergraduate chemistry courses, such as General Chemistry.

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Nonchemistry science majors often believe that the study of chemistry and Quantitative Analysis, in particular, is tedious, irrelevant, and simply no fun! Sometimes students are frustrated because learning Quantitative Analysis, which is inherently mathematical and involves considerable quantitative problem solving, requires a significant time investment including a great deal of outside-the-classroom practice solving problems. Often, these difficulties are complicated by the students' inability to relate the material presented in lecture to their future careers and the solution of significant real-world problems. All too frequently, these problems are accentuated because many college students never really learned how to study effectively while they were in high school.

Board games, such as Monopoly, and television game shows, like Wheel of Fortune and Jeopardy, have tremendous universal appeal. The format of many of these games lend them well to adaptation for educational purposes. The benefits of using games for learning are well-documented. They include increased student interest, motivation, and involvement [1]. For the last several years, I have used a modified version of Jeopardy to teach students how to study Quantitative Analysis and to have a good time doing it.

Jeopardy is particularly well-suited for this purpose. Contestants select answers to questions based on categories and question point values. The answer is displayed for all contestants to see and they compete to specify the correct question that relates to the displayed answer. Playing the Jeopardy game allows students to help themselves and each other, while enjoying their study time in the process. It provides for friendly competition, that helps takes the edge off of the more serious reason most students study, that is, the impending hour or final examination.

I have found that in the design of the questions used in the game, it is possible to demonstrate the relevance of the course material in the context of the solution of real-world problems. This is done by incorporating data from recent technical papers (from *Analytical Chemistry* or other analytical chemistry journals) as the basis for Jeopardy answers. This also gives students an introduction to the primary analytical literature and helps me keep current in the area.

The benefits of study groups are also well-documented [2]. The Jeopardy exercise facilitates their organization by relieving the tension of starting or joining one. The groups then provide a nonthreatening environment in which students learn how to teach themselves and how to teach each other. This helps build important team-working skills,

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which are oft cited as essential for a long and productive career in today's highly competitive technology marketplace [3,4].

Format and Rules for AC-Jeopardy

I suggest playing Jeopardy for one sixty-five-minute class period early in the academic quarter, immediately prior to the first hour examination. This allows the benefits of forming study groups for mastering the course material to be pointed out to the students. It also provides enough of a lead time for the students to derive maximal benefit during the entire academic quarter from the study groups that are formed as a result of this exercise. The game can be played for shorter time periods (i.e., 30 minutes), however, and can also be used effectively later in the course; for example, as a review for the course final examination.

At Northeastern University, about thirty students are usually enrolled in Analytical Chemistry I. I generally divide them into two teams of (as well as possible!) evenly divided ability. Depending on when in the quarter the game is being played and the personal "chemistry" that is observed between the students in the class, the teams can be selected by the instructor or the students can be allowed to form their own teams.

Students on each team are encouraged to work together to solve the problems. The first student to stand is given the opportunity to earn points for their team. If that student's answer (question) is correct, points are awarded to the student's team. The student, who gave the correct response, is asked to quickly present their correct solution to the entire class, so that everyone benefits from attempting to solve each problem. If the student's answer is incorrect, the first student on the opposing team to stand is given an opportunity to earn points for their team. In order to encourage full participation, once a student has correctly answered a question and earned points for the team, that student is disqualified from answering further questions.

The Jeopardy game board can be constructed by using standard 8-1/2 $\times$ 11 inch paper, taped sideways (landscape) to the blackboard at the front of the classroom. The top row of paper sheets is used to display the category names. Each sheet below a category displays the point value for a question (10, 30, or 70 points) according to the difficulty of the question (10 points = easiest question; 70 points = most difficult question). Each of these sheets represents a question and answer pair. One 8-1/2 $\times$ 11 inch sheet can be

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used to display either the category name or question point value using either 48- or 72-point type. Two or three sheets, taped top-to-bottom, may be required to display each question (answer).

The categories used in the Jeopardy game are based on the principal topics covered in the course. For example, some of the categories used include: Statistics, Spectroscopy, Gravimetry, Solubility, Acid-Base, Oxidation-Reduction, Separations, True or False, and Real World. Most of the categories are self-explanatory with the exception of the last two categories: True or False and Real World.

The True or False category contains statements on topics, involving any of the coursematerial, that the students must successfully identify as being either true or false. When the statement is false the team must correct the statement using a minimal number of words in order to produce a true statement. For example, true or false: “the pH at the equivalence point of the titration of a weak base using a strong acid decreases as the concentration of the weak base decreases.” The students would first have to state that the sentence was false and then correct the sentence. Obviously, there are several possible ways to correct the sentence. For example: “the pH at the equivalence point of the titration of a weak base using a strong acid decreases as the concentration of the weak base *increases*” or “the pH at the equivalence point of the titration of a weak acid using a strong base decreases as the concentration of the weak *acid* decreases.” More often than not, the statements are designed to be false. The need to correct the statement encourages more student discussion of the underlying concepts and produces greater comprehension in the end.

Real-world questions are based on current articles found in *Analytical Chemistry* that are relevant to the course material and which provide interesting applications of the topics presented in the course. Questions in this category often include figures and tables of data from the article. The students must analyze or interpret the data based on what they have learned in the lecture portion of the Quantitative Analysis course. Questions in this category are used as bolts to firmly anchor the course material to the real world. For example:

> Answer: The accuracy of a highly sensitive new technique involving flow injection analysis and chemiluminescence detection (FIA-CL) developed to facilitate the rapid determination of total dissolved iron in seawater aboard ship. Validation of the technique involved, in part, analysis of a trace metal

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standard (CASS-1) seawater solution. The results of this analysis, performed in triplicate, are shown below:

Comparison of the Total Dissolved Iron Content Determined by FIA-CL with the Certified Value.[a]

Standard Solution	Certified Fe Concentration nmole L^{-1} ± 95% Confidence Interval	FIA-CL Determined Fe Concentration nmole L^{-1} ± 95% Confidence Interval
CASS-1	15.63 ± 1.63	14.97 ± 1.84

[a]Elrod, V.A.; Johnson, K.S.; Coale, K.H. *Anal. Chem.* **1991**, *63*, 893.

In order to obtain the solution to this problem, the students must apply their newly acquired statistical arsenal to evaluate the accuracy of a new analytical method. In the context of solving problems in this category, such as the one above, student interest in the real world and in relatively new analytical methods is often piqued. This provides the instructor with a wonderful opportunity to go beyond the traditional limits of the classroom and to introduce students to cutting-edge research methodology and instrumentation.

Within each category there are three levels of difficulty: 10-, 30-, and 70-point questions. Two, three, or five minutes are allotted for students to answer each 10-, 30-, or 70-point question, respectively. Generally, 10-point questions are designed to be answered without requiring calculation. These are concept-based questions, which are used to evaluate an understanding of the fundamental concepts involved in the category topic. An example of a ten-point answer/question pair in the Chromatography category is:

Answer: In this type of chromatography the column packing is porous and analyte molecules too large to enter the pores are excluded and exit the column first.

Question: What is size-exclusion chromatography?

Thirty-point questions are usually based on one key concept and have been designed to require a minimal amount of calculation on the student's part. An example of a thirty-point answer/question pair in the Acid-Base category is:

Answer: The pH of the SHE reference electrode at standard state.

Question: What is pH zero?

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To successfully answer this question, the students must begin to integrate course topics, in this case acid-base chemistry and electrochemistry. An answer/question pair can be used as a bridge to encourage students to dig more deeply. For example, after students answer the aforementioned Acid-Base category question, I often ask the class to consider the implications of using a SHE as a reference when dealing with biological processes, which typically occur at pH 7.

Seventy point questions are the most difficult questions. These usually involve integration of more than one concept and sometimes a fair amount of calculation in order to obtain the answer. These questions are valued significantly higher in the point scheme in order to reflect both their difficulty and to make solving these problems more attractive in comparison to the quicker and easier ten- and thirty- point problems. An example of a seventy-point question in the statistics category is:

> Answer: Recently, there has been an interest in identifying a spectroscopic method to detect increased blood silicon levels in silicone-gel breast-implant recipients. Atomic absorption (AA) spectroscopy was one method investigated and the results of the analysis are shown below. Consider the ability of AA to detect statistically significant differences in blood silicon levels.
>
> ***Blood Silicon Levels in Control vs. Implant Patients Determined via Atomic Absorption Spectroscopy[a].***

	Controls ng mL^{-1}	Implants ng mL^{-1}
Result	6	7
Mean	25.42	27.11
Standard Deviation	8.3	6.72

> [a]MacDonald, P.; Plavac, N.; Peters, W.; Lugowski, S.; Smith, D. *Anal. Chem.* **1995**, *67*, 3799.
>
> Question: What is unable to detect increased blood silicon levels?

To earn points for this question the students must not only ask the correct question but also provide the correct analysis. In this case, to receive full credit the students must first obtain permission to compare the two mean values by demonstrating via the F-test that the precision in both sets of data are comparable. Then, the students must compare the two means using the T-test.

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Generally, the class does not have time to complete more than half of the questions on the Jeopardy game board during our sixty-five-minute class period. To encourage students to continue their study afterward, I generally make handouts with all of the Jeopardy game questions and answers available to interested students. This allows students to rework the problems we solved in the class period and it provides the students with additional similar problems that they can use to start discussion within their new study groups after the class period has ended.

I have investigated a variety of different methods intended to motivate students to fully participate in the Jeopardy game. The most well received rewards have been small university monogrammed novelties such as pens and key rings and a free hot pizza meal for the winning team. Good students usually recognize that the time and effort they expend in fully participating in Jeopardy will, in the end, benefit their study efforts. Most classes, however, contain at least one or more difficult students. One “stick” I have used effectively on occasion to motivate these curmudgeons is to inform the class at the outset that one or two questions similar to those in the Jeopardy game may appear on the impending hour examination. This usually motivates these students to take the game somewhat more seriously.

The Jeopardy exercise is easily adapted for use in large classes (100 or more students) and can also be modified for use in teaching other chemistry courses. This past quarter, I modified Jeopardy for use as an in class review tool for the final examination in General Chemistry II, which had a class enrollment of over 130 students. As in Analytical Chemistry I, students competed in teams. Due to the class size, however, I identified four teams based on student seating in the lecture hall. This approach worked well, at least with this particular group of students. Topics were identified based on the textbook chapters covered during the quarter. They included: Gases, Acid-Base, Kinetics, Equilibria (includes solubility), and Oxidation-Reduction. Due to the size and theater-style construction of the lecture hall, the Jeopardy game board with categories and question point values was handwritten on the blackboard. Questions and answers prepared using Microsoft PowerPoint were displayed on a large screen immediately to the right of the game board. Point values were erased from the board as questions were successfully answered.

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Students at all levels have expressed their satisfaction with the Jeopardy exercise. Students frequently form study groups after the exercise and the class as a whole is usually more comfortable asking and answering questions during the lecture period.

REFERENCES

1. Kramer, N. "Using Games for Learning" *J. Cont. Educ. Nursing* **1995,** *26*, 40.

2. Keats, D. W.; Boughey, J. "Task-Based Small Group Learning in Large Classes: Design and Implementation in a Second Year University Botany Course" *Higher Educ.* **1994**, *27*, 57.

3. Settle, F. "The Education and Training of Analytical Chemists" *Am. Lab.* **1995**, *27*(*9*), 7.

4. Sharma, J., Trankina, M. "Transferable Skills: A Scientist's Asset" *The Scientist* **1995**, *9*(*10*), 12.