

"Wild Ideas" Sessions in Teaching
Astronomy Courses

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Abstract

A new technique of teaching astronomy courses for science and non-science majors, so called personalized "wild ideas" sessions, is proposed. The brainstorming approach was developed and applied for teaching astronomy courses at ERAU, Eastern Region over the last 3 years. This technique represents an efficient and fun way to learn basic astronomical concepts and methods through a student's involvement in generating "wild ideas" about a given astronomical fact or set of facts, their analysis and verification. Basic elements of the technique and one sample session are described.

I. Introduction.

In teaching physics and astronomy courses for non-science majors, instructors usually encourage students to become scientifically literate in order to understand and appreciate new developments in science. Nowadays, with the large amount of information coming into the classrooms and textbooks every year it is difficult to navigate students in this ocean of new data and discoveries. The Internet provides easy access to a vast range of astronomical information at all levels and has been incorporated into many astronomy courses (English 1997). An introductory astronomy course often represents an introduction to science in general, and therefore, to the elements of the scientific method. Critical thinking becomes one of the priorities of education. This approach has been implemented by involving students in writing individual and “minute papers”, identifying and correcting misconceptions (Deming, 1997). An active learning supplement for an introductory astronomy course developed by McNamara et al. (1997) represents another example of critical thinking skill-building and model-building exercises.

During the last three years I have taught introductory astronomy courses at ERAU-Eastern Region, implementing the critical thinking approach through a “brainstorming” method. I have developed a new technique to teach physics or astronomy through a

student’s personal (logical and emotional) experience to learn the basic elements of scientific method. This technique implies an active way of participation in the classroom where the student is personally involved in the process of generation of ideas, their analysis and verification.

Generation of ideas and their verification are two important steps of the creative process in science and can be demonstrated in astronomy or physics courses while discussing possible interpretations of recent scientific discoveries. The data for testing and verification of these ideas often readily available over the Internet. An introductory astronomy course is usually one of the first science courses students take, so it is important to show how the elements of critical thinking and observational data analysis can lead to a scientific hypothesis and theory.

Brainstorming has been introduced by Alex Osborn, an advertising executive who believed that under the “right” circumstances, anyone could enjoy the rewards and pleasures of being creative. De Bono (1992) has argued that mental capacity and creativity can be improved with practice. I find that creativity is enhanced through sessions moderated by an instructor who encourages an emotionally relaxed atmosphere for student involvement in the generation and analysis of ideas. In this paper I develop this approach and propose it as a

new method, the **personalized "wild ideas" technique**, to teach introductory astronomy and science courses. Below I describe the basic elements of this process, followed by some sample problems and an example session.

II. Mechanics of a Brainstorming Technique

Brainstorming is proven to be the most effective with relatively small groups of students (< 30 students per group) and should be performed in a relaxed environment. This implies an instructor to moderate or ignite a brainstorming process and a chalkboard or white-board to write "wild ideas". Whole session lasts approximately 45-60 minutes and can be divided into three main phases: 1) Instructor's brief and concise description of the problem; 2) Shouting out and creating of a bank of "wild ideas"; 3) Verification of ideas. Personalization of the idea generation process is very important stimulus of student involvement. Always give credit to a student for his own ideas

Phase 1: Getting ready for the Session.

One of the most important phases of the method is a preparation to the session. An instructor is expected to refer to a given subject with a description of a problem situation presenting background information about the subject with all important

references (chapters in astronomy textbook) at Web Site one day prior the session.

In the beginning of a class the problem should be formulated and illustrated (!). It is instructive to use recent astronomical data. A number of public informational Web sites contain different kind of data and are currently accessible on the Internet. For example, the official Web site of Space Telescope Science Institute (URL address: <http://oposite.stsci.edu/pubinfo/>) contains latest Hubble Space Telescope data (high-quality images and spectra) and press releases about recent discoveries. The problem situation then can be defined in terms of "why", "what" or "which" key words referring to the real astronomical phenomenon or process. Clarity of a problem formulation is a very important to make brainstorming more efficient. I usually formulate a basic feature of an astronomical object under discussion in a single statement and present a basic information as a list of them (illustrated in Section III). Then after 10-15 minutes I ask student to shout out "wild ideas".

Phase 2: Shouting out "wild ideas"

Each "wild idea" generated by a student should be credited by the name of the author and listed on the board. In order to make Phase 2 successful students should be advised to:

- Listen carefully to the problem description and background information

introduced by your instructor. Clarify the formulation of the problem and ask yourself as many questions as you can to get the whole picture.

- Write down the problem and any important details. Keep the description as short as possible
- Write down two or more keywords describing a given process or phenomenon and try to combine them.
- Not to worry about style, just make sure you get the gist of the idea.
- Shout out the idea that can account for at least two features of a problem described by an instructor.
- No matter how silly or unworkable the idea is, a student must shout it out.
- Build on ideas of others combining two or more "wild ideas" ("superwild ideas").
- Not to criticize "wild ideas".
- Use a hint option provided the instructor who moderates a brainstorming session. Each idea generated during the Phase 2 should be named by an author and written down on a white- or blackboard. This inspires students to develop previous ideas, combine them or come up with an alternative idea. Depending on the psychological type, students have different attitudes to their own ideas. Some of them often prejudge their ideas negatively. Positive emotional atmosphere moderated by an instructor and an example of other students shouting out ideas encourages everyone

to overcome such an "emotional barrier" and become an equal creative thinker.

Phase 3: Verifying the Solution

Once we collect 6-10 "wild ideas" about the subject, the verification process is moderated by an instructor under the active student participation. Instructor discusses each "wild idea" to satisfy basic features described in Phase I. The crucial factor in selecting the best idea is a number of observational facts or experiments which could be explained consistently. Instructor subsequently throws out "dead ideas". Instructor comes up then with one or two best "wild ideas". The last step is to refer students to the actual source (scientific paper, press release, and book) to show that a final solution of the session is qualitatively consistent with accepted scientific interpretation of a given fact.

III. Problem Situations in Teaching Introductory Astronomy Courses

Below I present a list of problem situations which have been offered during the astronomy courses taught at the Embry-Riddle Aeronautical University, Andrews AFB and Naval Air Station, Patuxent River, MD. The problem formulation is usually supported by the image (or illustration) taken by ground-based or space-born telescopic observations (for example, the Hubble Space Telescope).

- Why several impact sites were observed

on Jupiter as Shoemaker-Levy comet collided with the planet? (picture taken by HST)

- Why Venusian surface is smoother than Mercurian one? (images provided by Magellan and Mariner satellites)
- How could it happen that the solar atmosphere is hotter than the solar surface? (picture of the solar eclipse)
- What causes the Sun to shine? (image of the Sun from SOHO satellite)
- Why most of the stars on the image of M16 (gaseous pillars) taken by HST are red? (picture of M16 taken by HST)
- Why white dwarfs are located at the cores of planetary nebulae? (picture of Helix nebula taken by HST)
- How to explain the presence of young "blue stragglers" in the center of globular clusters? (make use of the Press Release on HST site)
- How to explain observations of very narrow periodic pulses (with periods 0.3-3 s) coming from the central regions of nebulae? (image of the Crab nebula)
- How to understand a quasar miracle phenomenon, identical twin quasars AC 114 (6 billion light years away) or Einstein Cross phenomenon? (HST image)

IV. Sample Session: What causes the Sun to shine?

Phase 1. Background information.

Recent image of the Sun from SOHO

satellite data should be presented for illustration (available on the SOHO Web site).

- a. The Sun is made of the hydrogen (80 %), helium (19 %) and less than 1 percent of metals. The heavy elements amount only for one billionths part of its mass.
- b. The Sun is a very high-output factory of energy generation. It emits 2×10^{26} W while a regular power plant produces only a few hundred of MW (regular light bulb has a power ~ 100 W).
- c. The Sun has formed 4.5 billion years, which is only 1/3 of its expected life.
- d. The power of radiation emitted from the Sun is constant with accuracy less than 1 %.

Phase 2. Shouting out "wild ideas":

1. Chemical reactions release energy which eventually heats the Sun (**Jon's wild idea**).
2. Heating the Sun with comets and asteroids falling on it (**Carol's wild idea**).
3. Radioactive decay in the solar core. Something like an atomic bomb? (**Jim's wild idea**).
4. H-bomb in the solar interior or nuclear reactions can power the Sun (**Julie's wild idea**).
5. The collapsing Sun will heat the interior releasing gravitational energy (**Mark's wild idea**).
6. Matter - antimatter interaction can heat the Sun (**Sara's wild idea**).

Phase 3. Verification of □wild ideas□.

1. The chemical reaction, $2\text{H} + \text{O} = \text{H}_2\text{O}$ (water molecule), has one of the highest outputs.

Only one billionth of the energy spent we could get out from this reaction. That's is not going to keep our Sun shining for a long time, about 10,000 years or so. □ a

defective idea.

2. In this case, the kinetic energy of falling bodies is getting converted to the heat increasing temperature of the plasma, but in order to provide required heating rate we need millions of asteroids falling onto the Sun. The Sun emits 2×10^{33} erg/s. The falling body with the density 3 gr/cm^3 , size is about 10 meters, velocity is about 100 km/s has the kinetic energy only 10 orders of magnitude less than the solar emitting power in 1s. This means that we need to assume 10 billion asteroids or comets falling every second in order to provide the Sun with a required rate of heating. This is not supported by any observations. □ a **very defective idea.**

3. Heavy elements like uranium emit heavy particles (like helium) and transforming into less heavy element like lead. We have discussed that this process for the volcanic activity in the Solar system. This is very inefficient for the Sun because we need unrealistically huge (billions of times) amount of heavy elements to support the heating process. □ a **good looking but defective idea.**

4. Fusion produces energy by fusing together light particles like hydrogen into more massive particles like helium. H-bomb indeed utilizes a similar process to produces an

explosive and very efficient (a few percents) energy release. To start this process two protons should overcome their electric repulsion (us any like charges). To satisfy this condition protons should have high speeds (corresponding to $T \sim 14$ million K). To account for the required energy output we need a lot of them which can be created by the gravity force obviously only in the most densest part of the Sun, the solar core.

- a **good idea.**

5. Nice idea and we can really get enough energy out of this process per unit time converting potential energy of falling plasma into the kinetic energy, but it is not going to last longer than several hundreds of thousands of years. □ a **defective idea.**

6. Practically, 100 percent of the energy can be converted into the heat accounting the Sun shinning for billions of years. Unfortunately, there are problems with this because the number of heavy particles in the Sun must stay the same and very soon the matter-antimatter reaction would violate that rule and nature would not go for it. □ A **defective idea.**

Final selection: Idea #4 is the most promising candidate to solve the problem.

V. Conclusion

The version of a brainstorming session as proposed here is targeted to improve the teaching process for introductory science courses. The implementation of the "wild ideas" technique at ERAU, Eastern Region has shown that:

1. Creativity of students has been increased through the phases of generation, analysis and verification of the "brainstorming" sessions. This is a risk-free opportunity for students to reveal their personal ideas without being criticized. "Right" circumstances created during a session help students to reveal and developed their creative abilities. Students usually become actively involved by the second or third session. I describe student creativity in terms of the number of successful ideas generated by a student during the sessions and in term papers.
2. The "wild ideas" session increases student involvement in seeking the "truth". Class attendance and student performances have been increased compared to the astronomy classes taught by "traditional lecture" approach.
3. The "wild ideas" technique in particular increases student-instructor and student-student interaction. This method has proven to be a good way to convey the basic course material. The intense interaction with each other and the instructor makes the learning experience memorable while teaching constructively

critical thinking. I have observed that students sometimes stay after class hours for informal discussions.

More information about the implementation of the "wild ideas" technique can be found on my personal Web Site

<http://hrssun.gsfc.nasa.gov/~vladimir/vlad.htm>
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