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What if Fossils Are Discovered On The Planet Mars?
A Learning Activity for Promoting Critical Thinking and STEM Education

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ABSTRACT

This paper outlines a role-playing scenario to help students build a better understanding of scientific concepts and principles. In this scenario, students are part of the scientific, economic, political, philosophical, religious, social, and media communities. These communities are faced with challenges about the new fossil discoveries, bacteria and bone fragments, as well as plant parts found on the planet Mars. In this activity, students will assume roles as the representatives of these communities. After doing research, they will develop a plan and strategy for the members to present how their respective communities would react to the newly discovered fossils on Mars. To accomplish this goal, students will work together to collect information and acquire the knowledge that will help to put them in the shoes of the members of their prospective communities. They will develop informative and realistic perspectives that can be presented on behalf of the given communities. They also will learn to take on the roles of others and improve their social skills and academic performance. By actively engaging in this activity, students learn and reinforce their understanding of various concepts in science and how science interacts with various aspects of human endeavors. But most of all, we aim to invoke an interest in learning about the fossils and fossil formation, planet Mars, and the concept of life and space exploration and in turn, excite students to learn about issues that they are likely to find themselves apart of in debate. Thus, this scenario encourages students to become informed citizens, who hopefully are capable to see multiple paths to an answer for a given problem in highly competitive global world.

Keywords: Role-play, Fossil, Planetary Science, Space Exploration, Human Settlement on Planets, Student Motivation and Engagement, Students Learning, Civic and Community Engagement, Deep Learning.

Introduction

According to American space agency (NASA) officials, the new NASA Mars Science Laboratory (MSL) Rover, which weighs 22,000 pounds and costs $2.2 billion, was built and launched on a Mars mission in 2011, and successfully landed on the planet in 2012. Since landing, it has sent back a wide array of data to suggest that Mars, in the past, had an environment suitable for the development and sustaining of life, with abundant liquid water and a moderate pH (Grotzinger, *et al*, 2015). These exciting results suggest that even more discoveries wait ahead, both for MSL as it continues toward its ultimate destination of Mt. Sharp, and for future unmanned landers now in planning. Many have argued that establishing a human settlement on Mars must become the next giant leap for mankind. Indeed, the "Mars One" project which aims to establish a permanent human settlement on Mars by 2026, is proposing to launch the first unmanned mission to Mars by 2020 to start the creation of a reliable living environment for astronauts who will leave Earth starting in 2024. The idea is that the first crews of four will depart in one-way journey to start the first human settlement on Mars. After the initial crew has left for Mars, a new crew will depart every 26 months (Cruddas, 2015; Mars One 2015). Placing human explorers on Mars would undoubtedly accelerate the rate of new discoveries about our neighbor in space. **And what if one of the discoveries happens to be that fossils, of both microbial and macroscopic life forms, are present on Mars?** While the odds against such a discovery are enormous (at least for now), the possibility of such a discovery raises fascinating questions in a wide variety of human interests. Also, because we think Mars is not inhabited by life at present, a discovery of ancient life on Mars would make us think seriously about how to prevent our planet from becoming devoid of life, like Mars. Concepts like these require us to consider a complex web of scientific, technological, social, economic, political, and philosophical implications.

Fossils are casts, impressions, actual remains, mineralized or replaced remains, or other signs or traces left by once living

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organisms, preserved through geological time (10,000 years or longer), in the rock record. Given the number of living organisms that have ever lived on planet Earth, fossils are surprisingly very rare, and there is no reason to speculate otherwise for any other planets. This is simply because, first, an organism must be fossilized, which is not an easy task, and second, after being encased in stone, the organism must wait until the surrounding rock material erodes away, exposing the fossil to the eyes of enthusiasts and explorers, both casual and professional (Rhodes, Zim, and Shaffer, 1962). Putting it simply, as Bill Bryson (2003) has done:

> *The fate of nearly all living organisms- 99.9 percent of them - is to compose down to nothingness. When your spark is gone, every molecule you own will be nibbled off you or sluiced away to be put to use in some other system. That's just the way it is. Even if you make it into the small pool of organisms, the less than 0.1 percent that don't get devoured, the chances of being fossilized are very small. ... [For example,] Only about one bone in a billion, it is thought, ever becomes fossilized. ... Moreover, the record we do have is hopelessly skewed. Most land animals, of course, don't die in sediments. They drop in the open and are eaten or left to rot or weather down to nothing. The fossil record consequently is almost absurdly biased in favor of marine creatures. About 95 percent of all the fossils we possess are of animals that once lived under water, mostly in shallow seas.*
>
> *(2003, pp. 321-322)*

Furthermore, while plant life has always been the basis for animal life on planet Earth, and is now (and probably always has been) much more abundant, we find many more animal fossils compared to plant fossils, because of the difficulties of preserving plant remains or traces. Thus, the history of plant life on our planet is relatively unknown (Rhodes, Zim, Shaffer, 1962, p.150). There is, again, no need to believe otherwise for other planets in our solar system, even if they are inhabited now, or were so in the past.

While today the Martian surface is uninhabited, and probably too harsh to support any type of life form as we know it, high-resolution pictures of the planet Mars provided by the Mars Global Surveyor spacecraft (MGS) and other sources have already shown how similar Mars could have been to Earth. This realization is based on the evidence of the widespread presence of sedimentary rocks laid down by ancient lakes and shallow seas. New chemical and mineralogical data from the MSL Rover have shown the abundant presence of hydrated minerals (clay), and other minerals indicative of water-rich environments like on Earth (Grotzinger, *et al*, 2015 and others). This irrefutable evidence of sedimentary rocks on Mars is supported by what we already know of our own planet--that sedimentary layered rock structures occur primarily where there were once lakes or oceans. The second kind of evidence is the strong possibility that water may have flowed on the surface of Mars in the recent geological past. Indeed, a comparative analysis of photos taken in the same place four years apart by the Mars Global Surveyor shows that deposits have formed in Martian gullies during the past seven years which lead some scientists to speculate that liquid water may exist right now on Mars (Minkel, 2009, p.26). These two phenomena (sedimentary rock and flowing water) are part of the requirements for the presence of fossils on planet Earth and, in turn, a proven record of the history of life on our planet.

Like on Earth, scientists strongly believe that the sedimentary rock on Mars has preserved a record of events that occurred on that planet in the past. Thus, many have convincingly concluded that "the sedimentary rocks are now the place to look for evidence of past life on Mars" (Whitehouse 2000).

With the discovery of sedimentary rock and the possibility of flowing water in the past *scientists are hoping that on Mars, "similar deposits may stretch back 3.5 billion years to a time when Mars was warmer and wetter, [with a thicker atmosphere], and possibly life." (Whitehouse 2000, ¶. 11)*. Certainly if life ever existed on the Red Planet, *"the fossil evidence would most likely be found in the types of sedimentary rock just imagined" (Whitehouse 2000, ¶. 4)*. On Earth, the oldest known fossils are the remains of prokaryotes, (most likely cyanobacteria), that are found in rocks in Western Australia and widely believed to be 3.0-3.5 billion years old (Tortora, Funke, and Case, 2007). Furthermore, bacteria spores 40 million years old were "extracted from a fossilized bee and successfully germinated by US scientists in 1995" (QPB, 1998, p. 71). In the case of Mars, some astronomers claimed in 1996 to have evidence for microfossils in a Martian meteorite. Their claim, although not proven, has not been totally discounted (Whitehouse 2000, ¶. 3).

Learning Activity

In this activity, we will assume that NASA's Mars Science Laboratory Rover has discovered a number of fossils, including several types of bacteria, unidentified shell fragments, and unidentified plant parts in the sedimentary rock layers of the planet. The students will be given the opportunity to work in teams, which will require them to practice collaboration, conflict resolution, and practical approaches to solving problems. In taking on this project, our hope is that students will strengthen their abilities to think critically, communicate clearly, learn self-discipline, develop an understanding of themselves and others, and cultivate the habit of self-education (Cherif and Somervill, 1994; Joyce and Weil, 1986).

Scenario

The NASA Mars Science Laboratory Rover, which has successfully landed on Mars a few months ago, has made significant discoveries of numerous fossils, which scientists have identified as bacteria, shell fragments (exoskeleton), and plant fossils. While the bacteria fossils are very clear and identifiable, and represent multiple species or varieties, the shell fragments and the parts of plant fossils are not identifiable as to what living organism they derive from. But there is no doubt that they are shells and plant parts, based on multiple analyses of their mineral compositions, as well as the visual impression of the remains.

Seven groups (Table 1) are asked to identify the significance of these discoveries as well as predict how their respective communities would react to these discoveries. These groups are:

1. Biological Science Community Group: This group consists of evolutionists, microbiologists, botanists, zoologists, physiologists, molecular biologists, geneticists, etc.
2. Physical Science Community Group: this group consists of geologists, archaeologists, astronomers, cosmologists, chemists, physicists, aeronautical engineers, paleontologists, etc.
3. Theologian Community Group: This group includes members who might belong to the Jewish, Christian, Muslim, Hindu, Buddhist, or other faiths, and/or scholars who specialize in the study of one or more of these faiths, as well as in natural theology.
4. Economic Community Group: This group includes members who might belong to or espouse a free-market economic system, a socialist economic system, a communist economic system, or another variety of a government-controlled system.
5. Political Science Community Group: This group includes members who might be focused on political and social issues, either in academe or in the real world of community affairs or political campaigning.
6. Philosophy Community Group: This group includes members who might be interested in ancient, modern, or post-modern philosophy in their personal lives or in academe.
7. Media and Investigative Reporting Group: This group consists of those interested in or practicing in the spheres of the written media (newspapers and magazines), audiovisual media (radio and television), or Internet and Web-based media (blogs, etc.).

The goal of the media and the investigative report group is to make sure that the public are aware and informed about what is going on as well as fairness and transparency. Through their reporting, coverage, and investigative reporting, the media group helps to enhance understanding and promote active dialogues between the public (as planetary citizens) and the members of the other groups that shape and influence our current culture and life styles. The groups were encouraged to add to their members (if needed) a mathematician or statistician.

Pedagogical Strategy

This role-play learning activity can be carried out effectively either in one class meeting, which takes between 90-150 minutes, or in six class meetings, with 15-30 minute periods at the end of each class meeting. In the first pedagogical approach, all the groups present the perspectives of their community in the same day. At the end of the presentation, the media group presents detailed written and oral coverage of the event. On behalf of the public, the media group is also responsible for raising questions that they think are important and those which the members of the other groups have failed to raise or address adequately. In doing so, the media helps to promote fairness and transparency within the communities.

Table 1: The Selected Communities and Their Practitioner Members

	Community	Community Practitioner Members	Number of Representative
1	Biological Sciences	Evolutionists, microbiologists, botanists, zoologists, physiologists, molecular biologists, astrobiologists, geneticists, bioengineers, and paleontologists.	
2	Physical Sciences	Geologists, archaeologists, astronomers, space scientists, chemists, physicists, cosmologists	
3	Political Science/ Politics	Political scientists, politicians	
4	Economic Community	A free-market economic system, a socialist economic system, a communist economic system, or another variety of a government controlled system.	
5	Theologian Community	Deacons, priests, bishops, pastors, ministers, rabbis, imams, ayatollahs, ulema, sangha, jathedar	
6	Philosophy	Pre-modern philosophy and post modern philosophy.	
7	Media and Investigative Report	Journalists, broadcasters, investigative reporters	

In the second pedagogical approach, in the last hour of each class meeting, one of the groups will present the perspective of its community. At the end of the presentation, the members of the group answer questions raised by the members of the other groups. At the end, the media group presents detailed written and oral coverage of that day's event. Again, on behalf of the public, the media group is responsible for raising questions that they think are important and those which the members of the given group have failed to ask.

This learning activity, however, starts with two optional, yet important warm-up activities and homework assignments which take place before the scenario begins (See appendix 1). The first one is called "What is life or being alive"? While the second one is titled "How well do you know your surrounding community?" The goal of the first warm-up activity is to have students start thinking about life in a way that they might have never thought of it before. Furthermore, this activity should encourage students to appreciate life, which as Isaac Asimov questions, "What can be more important than the science of life to any intelligent being that has that good fortune to be alive?" The aim of the second warm-up activity is to make students aware of the professions in their surrounding communities and the role they play in the everyday life of their society. The activity generates information that can be useful when the members of the given groups make decisions and choices in selecting representatives for their community.

Learning Activity: What if Fossils Are Discovered On Mars?

Procedures:

I. Before the Enacting Procedures

1. Divide your class into seven groups. Each group consists of a leader plus a few members based on the nature of the community and the needed number of adequate representation. Biological Sciences Community, Physical Sciences Community, Religious Community, Economic Community, Political Science Community, Philosophy Community, and Media. Depending on class and group size, each student may have to play more than one role.
2. Inform the students in the scenario that the NASA Mars Science Laboratory Rover, which successfully landed on Mars several years ago, has made significant discoveries of a number of fossils, three of which scientists have identified as bacteria, shell, and plant fossils. While the bacteria fossils are very clear and identifiable, the fossils of the shell fragments and the fossils of the plant parts are not identifiable as to which living organism they derive from. If needed, mathematician can be added to the members of a given community.
3. Inform the students that as active members of their respected communities, they are to present the news of the fossil discoveries on Mars to their respected communities. They should identify the significance of these discoveries for their particular community as well as predict how their respective communities would react to the discovery of the fossils that was made by the NASA Mars Science Laboratory Rover.
4. Give the groups 2-3 weeks to prepare for their class presentation. In addition to working outside the class time, make sure that each week they set aside 10-15 minutes of the class time for the members of each group to join together and discuss their work and preparation. This way, you ensure that the groups are working on task and will be ready on time for the day of the presentation.
5. Ask the members of each group to meet and divide the roles between themselves by selecting a leader for each category, as well as which areas within that category they would like to represent. For example, in the biological science community, they could select evolutionists, microbiologists, botanists, zoologists, physiologists, molecular biologists, and/or geneticists. In addition, the members of a given group must make their own choice about the type of bacteria, and decide where the animal fragments and plant part fossils came from. Using table 3 below, each group must justify their selection in writing. This type of involvement is very critical in ensuring high level of "Student -Involvement in the Learning Activity".
6. For the presentation, each group must:
   a. Have a well researched presentation and strategy of how to present their respective community's views and reaction to the new fossil discoveries.
   b. Explain how their respective community's views and reaction to the new fossil discoveries might influence the general public.
   c. Explain how the public might react to their respective community's views and reaction to the new fossil discoveries.
   d. Prepare a well researched student hand-out as well as an illustrated poster.
   e. Integrate the use of technology such as PowerPoint, animations, interactive activities, etc. into the presentation. Students should present their plan and strategy, show how they will work, and convince everyone that the new fossil discoveries support their community's beliefs and understandings.

Table 3: Selected Categories within Chosen Communities

		Biological Science Community	Physical Science Community	Political Science Community	Economic Community	Theologian Community	Philosophy Community	Media Group
1	Selected Category Representatives							
2	Reasons for Selecting Those Category Representatives							
3	Fossil of bacteria							
4	Fossils of Bone Fragments							
5	Fossils of Plant Parts.							
6	Reasons for Selecting Those Types of fossils							

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II. During the Presentation

1. The groups take turns presenting to the whole class the significance of these discoveries as well as the prediction of how their respective communities would react to the new fossil discoveries.
2. The leader of each group introduces the members of his or her team, and provides a brief introduction. Then, the leader of the group can call on the members of his or her group to talk about the significance of these discoveries as well as the prediction of how their respective communities would react to the new fossil discoveries.
3. The members of the other groups can ask up to three questions after a given group finishes their presentation. The members of each group must also take notice of all the questions that were asked by all the groups.
4. When all the groups finish their presentations, the media group reports on the events and provide a list of questions that the members of the communities failed to raise, answer, and/or shied away from discussing.

III. After the presentation

1. Following the class meeting, the members of each group community bring answers to the questions that are raised and presented to them by the media groups.
2. Each group is given 3-5 minutes to address the class one more time. In this short final remark, the groups must have a written statement that can be read to support their views and understanding. The written statement doesn't have to be shared with the other groups beforehand. This is a very important stage in the activity and is related to the "Creative Domain" of McCormack and Yager's (1989) taxonomy for science education, as we will see in the coming assessment section.
3. After all the groups present their final remarks, the groups are asked to evaluate in writing the performance of each group.

Assessment

As we have done in a number of learning activities such as this (e.g., Cherif, *et.al*, 2009; Cherif, Verma, and Somervill, 1998; Cherif and Somervill 1994, 1995), we suggest the use of McCormack and Yager's (1989) taxonomy for science education as a framework for students achievement, and for assessing students performance and understanding, as well as for the effectiveness of the activity. After all, we teach so the students can learn, and to learn is to:

> *... acquire understanding of something that one didn't have before. One may learn propositions (that such and such), skills (how to do something), or to recognize things. What is involved in learning certain particular things (e.g., moral theory) may indeed lead to conceptual problems; but there is no real conceptual puzzle about what is embodied in the idea of, for example, acquiring understanding of a proposition.*
> *(Barrow and Milburm, 1989)*

Because of this the teacher and students should explore how and why each group reached their decision, and whether this whole situation could have been approached in other ways (Joyce and Weil, 1986). The Table 4 below summarizes the McCormack and Yager's (1989) taxonomy for science education as a framework for assessment which could be accomplished as both formative (which conducted during instruction) and summative assessment (which conducted at the end to measure what was learned).

Student-Level of Involvement in the Learning Activity

Teaching approaches should seek to capture the student's interest and spark motivation for learning and knowledge creation among students. To achieve this, students should be given the opportunity to be involved in the planning, implementation, and assessment of a given learning activity.

> *To make the teaching approach of the given learning activity more productive, teachers should lead students toward greater levels of involvement in the process by including them in planning the five factors that make up a typical role-playing situation: 1) the problem to be solved; 2) the characters to be played; 3) the roles to be followed; 4) essential information to be gathered and; 5) procedures for the play to be adapted (Cherif and Somervill, 1994, 1995).*

Therefore:

> At the first level of "Student-Level of Involvement" in the "Role *Playing Teaching Model" as shown in Table 5, students carry out pre-assigned activities: they are actors for a scripted play. The educational value of the role-playing activities increase as the procedure encompasses greater levels of student involvement. For the highest productivity, instructors should lead students toward level 6, even if that level cannot be achieved. As the difficulty level increases, so does the amount of time, effort, and best of all, enthusiasm among the students. The final level of student involvement is critical assessment.* (Cherif, *et. al,* 2009, p. 345)

In this activity, the problem to be solved and the characters to be played are given to the students. However, the roles to be followed, the essential information to be gathered, and the procedures for the play to be adapted are part of the learning activity and the students responsibilities. Thus it is at the fourth "Student-Level of Involvement" in the learning activity. This is another good reason to try this activity with your students. (Cherif, *et. al*, 2009, p. 345)

Tables 6 and 7 have been used successfully as tools to record information and to monitor the level of cognitive involvement of the members of a given group during the activity. For example, using table 6, instructors can record the type of questions being asked by the members of a given group as well as the relevancy of the questions to the subject matter and to the point being addressed. Furthermore, using table 7, instructors can record the number of questions being asked by the members of a given group to the other groups (Cherif, *et. al*., 2009).

A pre- and post-test Homework Assignment

To reinforce the learning objectives of the activity, and to allow for compelling attitudinal change, ask the students to answer the following questions, either individually or in groups.

i. A Pre-test Homework Assignment

1. What will you do to make sure that the perspective and the reaction of your chosen community would be the one favored by each one in your class?
2. What will you do to make sure that you are selecting the right categories of representatives within your chosen community?
3. If you decided to adopt a real and well known person from your community, what will you do to make sure that you are selecting the right categories of representatives within your chosen community?
4. What do you think you will learn from the activity at both the academic and personal levels?

ii. A Post-test Homework Assignment

1. What have you learned from the activity at both the academic and personal level?
2. If you had to do this all over again, what would you change or do differently and why?
3. Knowing what you already know, how would you argue against the perspective and the predicted reaction of your own community?
4. If you have selected an actual well known person from your chosen community, how did this help you to convey the perspective of your community?

Table 4: Summary of McCormack and Yager's (1989) Taxonomy for Science Education as a Framework for Assessment

	Domain	Description	Type of Questions That Can be Looked At.
I	**Knowledge Domain**	Students acquire knowledge of the subject, an understanding of relationships between the bodies of knowledge, and give reasons for their approach to solving the problem.	What concepts did students learn and how well did they understand them? How well did the students integrate knowledge from different subject areas? To what extent did students demonstrate the understanding of multiple relationships of various bodies of knowledge? Were the students able to disprove or verify some of the supporting theories used in the role-playing activity? What kind of explanations did students offer for the relationship they observed and understood?
II	**Process Domain**	Students learn how to collect, organize, and analyze data; develop strategies for building rational arguments and thoughts; state problems and generate valid conclusions; participate in team-work; interpret meaning from the project.	How did members of a given group compile data and information? Was there cooperation in putting the information together? How efficient was each group in presenting and communicating the collected data and information? Was their delivery of statements and arguments smooth and coherent? How well did the students use knowledge meaningfully? Did all members participate in the activity?
III	**Creative Domain**	Students apply creative thinking to the project; cultivate the ability to recognize, evaluate, and use data and information provided by the other parts of the role play; learn to modify a given design as needed.	In what new ways did students use objects and ideas generated during the enactment of the role-playing to enlarge their understanding? How imaginative were students in identifying relevant problems, solutions, and conceptualizing new ideas?
IV	**Attitudinal Domain**	Students learn to listen closely and comprehend the other parts of the role playing. They also learn cooperation in a group performance and self-evaluation.	How persuasive were group members in articulating their positions in order to change the attitudes of the others? How effectively did each group function? Did students' sensitivity and respect for others develop during the process? Did members of a given party demonstrate skills and abilities to resolve conflicts with others constructively? How might each group have functioned more effectively?
V	**Application and Connection Domain**	Students learn to generate alternative approaches, problem-solving strategies, and solutions.	Did they come up with practical and workable solutions? To what extent did the students utilize their personal experiences and collective group understanding in making decisions related to the activity? How well did the students integrate knowledge from different disciplines in problem-solving strategies? How well did the students learn to negotiate constructive solutions to conflicts?

Table 5: Student - Level of Independence in the Role Playing Process (Cherif and Somervill, 1994, 1995)*

The Level Of Involvement	Problem To Be Solved	The Characters In The Play	Role of The Characters	Essential Information	Procedures For The Play
I	Given	Given	Given	Given	Given
II	Given	Given	Given	Given	Not Given
III	Given	Given	Given	Not Given	Not Given
IV	Given	Given	Not Given	Not Given	Not Given
V	Given	Not Given	Not Given	Not Given	Not Given
VI	Not Given	Not Given	Not Given	Not Given	Not Given

** While individual students are expected to achieve various levels of involvement in the learning activity based on the grade levels, intellectual maturity, etc., the activity should be considered successful if, for example, AP classes can reach level I or II, freshman in college can reach level III and upper-classmen can reach levels IV and above.*

Table 6: Individual group questions analysis and account.
(*Cherif, et. al, 2009, p. 345*)

	Type of Question	Extremely Relevant	Relevant	Not Relevant	Total of Questions
1	Why				
2	How				
3	Which				
4	What				
5	When				
6	Where				
7	Is/Are				
8	If…, then… Inquiry wondering statements				
9	Total of questions and or wondering statements				

Table 7 - Tracking the number of question asked by each group of other groups
(*Cherif, et. al, 2009, p. 345*)

Community Groups	Biological Science Group	Physical Science Group	Political Science Group	Economic Group	Theologian Group	Philosophy Group	Media Group	Total Questions
Biological Science Group	X							
Physical Science Group		X						
Political Science Group			X					
Economic Group				X				
Theologian Group					X			
Philosophy Group						X		
Media Group							X	
Total of Questions								

Discussion Questions

1. What are the characteristics and the properties that make the planet Earth well suited for life as we know it?
2. What are the differences and the similarities between the characteristics of life and the characteristics of living organisms on the planet Earth?

3. What should we look for when we search for signs of life and life forms, both those familiar to us and those that are alien to us, on other planets?
4. Define 'fossil,' compare and contrast the different types of fossils, and then explain why scientists study fossils.
5. Bill Bryson (2003) has stated that it "ISN'T EASY to become a fossil. The fate of nearly all living organisms- 99.9 percent of them—is to compose down to nothingness."(pp. 321-322). Because of this, fossils are very rare. What will it take for a given object to become a fossil?
6. It has been argued that the fossil record "consequently is almost absurdly biased in favor of marine creatures. About 95 percent of all the fossils we possess are of animals that once lived under water, mostly in shallow seas". (Bryson 2003, pp. 321-322) Why are plant fossils less numerous, especially when plant life has always been the basis for animal life throughout Earth's recorded history?
7. Dr. Francis S. Collins, one of the country's leading geneticists, and longtime leader of the human Genome Project, proposed "Biologos" in his latest book, The Language of God: A Scientist Presents Evidence for Belief (2006). Dr. Collins has argued however, both the scientific community and the theologian community might have a strong objection and or concern about his proposal.
   a. Conduct Internet research to find out what "Biologos," proposed by Dr. Collins (2006) is.
   b. Why do you think Dr. Collins (2006) believes that his proposal might encounter strong objections from both the scientific and the theologian communities?
   c. Do you agree or disagree with Dr. Collins' proposal and why?
   d. Do you agree or disagree that "Biologos" might encounter strong objections from both the scientific and the theologian communities?
8. If the scenario in this learning activity is true, how do you think this discovery will change the world politically, economically,culturally and socially, scientifically and technologically, and theologically? Use Table 8 for your answers.
9. How many students in your class do you think will agree with your deductions? Explain.
10. What rights do we have to go to, inhabit and alter other planets that:
    a. Have already been inhabited by human beings like us?
    b. Have already been inhabited by other life forms, but not human beings like us?
    c. Are not inhabited by any form of life as we know it and as far as we know?
11. In what way would the news that the discovery of fossils on planet Mars was not true be a disappointment to any of your communities? Explain. Use Table 9 below for your answers.
12. Which community do you think would be the least disappointed if the news that the discovery of fossils on planet Mars was not true? Explain. Use Table 9 below for your answers.
13. In his book *The Panda's Thumb*, the well known paleontologist and writer, Stephen Jay Gould (1992), wrote that: "If we are still here to witness the destruction of our planet [by the Sun] some five billion years or more hence, then we will have achieved something so unprecedented in the history of life that we should be willing to sing our swan song with joy." (QPB, 1998, p. 286).
    a. Why do you think Stephen Jay Gould holds this belief?
    b. Do you agree or disagree with Stephen Jay Gould's belief? Explain.
14. Write at least two to three paragraphs to explain what you have learned from this activity.

Table 8: Student's deductions of the effect of the discovery on the world politically, economically, culturally, scientifically/technologically, and theologically

The Discovery's Effect on the World	Your Deductions	Students Agree with Your Deductions	Students Disagree with Your Deductions
Politically			
Economically			
Culturally/ Socially			
Scientifically / Technologically			
Theologically			

Table 9: Type of disappointments various communities might develop if these discoveries turned out to be untrue

		Community's Group	Explanation
1	Your Own Group		
2	The Group would be the Most Disappointed		
3	The Group would be the Least Disappointed		
4	The Group Would be Neutral		

Final Remarks

Climactic status and in turn, the long term sustainability of life as we know it on our planet Earth, has been justifiably questioned, and our own collective behavior as humans has been identified as one of the critical factors behind this forewarning. The significance of discovering any sort of fossils on Mars is not only important in learning about the history of life on Mars, but it can help us learn how to prevent our own planet from becoming uninhabitable like the Red Planet; how to make space explorations more effective; and how to make the search, terraformation and colonization of other earth-like planets possible in the future. But first, we must figure out how to get there quickly and safely and how to sustain ourselves as we travel back and forth between planets, and second, we must determine what to look for, how to look for it, and how to recognize that something might be an indicator or hold significant clues for life in outer space.

Biologists have been exploring life using a combination of three approaches: functional, genetic (molecular / informational), and structural. The functional approach to life demonstrates that all living things share four basic properties: metabolism, adaptation, reproduction, and variation, which leads to evolution. The genetic approach to life looks at the origin and development of living things through molecular data and information. The structural approach recognizes that the functional unit of living things is the cell.

Even though the fossil record is not a list of orderly dates and places, and the fossils themselves are as dead as any stone we can think of, fossils are one of the best tools for studying and understanding the history of life, its evolution and diversity. Fossils are not only alive in the metaphoric sense, but they are the only reliable tool for understanding the history of life on the planet Earth, as well as on any other planet. Using Nicholas Wade's (1998) words: "To hold a fossilized ammonite or shark's tooth in your hands is to witness the death of a creature that died tens or hundreds of millions of years ago, an event that transcends historical time. You may wonder at the beauty of a structure built of stone, or at the accident by which this one individual among the vanished millions of its kind left a permanent trace of its existence." (p. 1)

Even though scientific understanding or explanations might still be lacking for many questions in our minds, science, as Collins (2006) has explained, is "the only reliable way to understand the natural world and its tools when properly utilized can generate profound insights into material existence." (p. 6). This is because as Margulis and Sagan (2001) have argued,

> *Science is an intensely social activity, a group enterprise based on observation and consensus, methodical checking and rechecking, it compensates for limited individual perception and cultural superstition. Science admits occasional flashes of insight with which a new, more fruitful way of looking at the world is transmitted first to scientists and eventually to their public. (p. xii).*

However, "all the sciences have changed profoundly again and again throughout history. This process of change happens not simply because more knowledge is acquired, but because new knowledge continually raises new questions, sometimes at such a fundamental level that the entire set of assumptions underlying science shifts to a new pattern of understanding." (Carr, *et. al*, 2001, p.3-4).

We hope that through the challenges presented in this learning activity, students, who are our future scientists, engineers, politicians, economists, civic leaders, theologians, etc., will be able to think beyond their foresight and always consider the unthinkable and explore on behalf of the well being of humanity, the known and unknown planetary citizens.

This of course, as Press (1990) argued 25 years ago, requires that:

> *...difficult policy decisions must be made on the basis of judgments between dimly perceived future risks and possible economic or other consequences that may be more immediate. While these decisions must be based on the best information that science has to offer, scientists are no better qualified than other individuals to hammer these difficult judgments alone. It is important that the public also become informed and involved in making these choices and shaping the necessary policy decisions. (p. iv).*

Finally, the related learning activities that we provided as a follow up article of collection activities in this issue of the journal (Cherif, Adams, Movahedzadeh, Jeremy 2015) could be used to help make student's learning experiences richer both in the development of breadth of knowledge and the depth of understanding of their own invention and creation. Instructors are advised to select those learning activities that are more relevant to what they are teaching and to what they want their students to achieve. The other goal is to motivate students to engage in knowledge searching and generating by reading a wide-range of sources beyond just their own textbooks, such as their favorite newspapers, magazine, blogs, TV-shows, and radio stations.

Appendix I

Warm-Up Activity

Warm-Up Activity 1: "What is life or being alive?"

(Adapted from Cherif, Doering, and Ross 2001, p. 1-20)

With no warning or preparation, ask your students to get a pen and piece of paper and be ready to answer the following questions you are about to ask them.

1. Define life from your own perspective and write it down.
2. Is your definition of life "Functional," "Structural," "Conceptual," a combination of the two or three definitions," or "None of the above?" Explain.
3. Discuss your definition of life with the members of your group.
4. How did the discussion with the members of your group affect your definition of life? Do you feel like you need to make some changes in your definition? If yes, please do so.
5. Using your final definition of life, colored pencils, and an 8x17" sheet of paper, draw two pictures of the same organism (dog, bird, cat, fish, lizard, fruit fly, tree, etc.). One picture must illustrate the living organism and the other picture must illustrate the dead organism. Under each picture, write down the reasons you think one is alive and the other is dead. Discuss your reasons with the members of your group before you write them down.
6. Please re-examine your definition of life again and then answer the following questions:
    a. Are you satisfied with your answer? Yes or No? Explain.
    b. Did you manage to completely distinguish between the live one from the dead one? Yes or No? Explain.
    c. Have you said enough about the differences between the two? Yes or No?
7. With an open mind, discuss your answers with the members of your group, then answer the following questions:
    a. In real life, and with the same conditions that you attach to the two drawings, are the two made of the same way: have similar skeletons, internal organs, body fluids, skin, fur, feathers, stem, leaves, roots, etc.? Yes or No?
    b. Are there any missing parts in any of them? Yes or No? Explain.
    c. If you had the ability to analyze them chemically, would you find them made from the same substances? Yes or No?
    d. If they were the real organisms, as you illustrated them, what would happen if you tried, for example, to set them up to stand?
    e. Why would one of them fall over every time and the other stay up?
8. Please discuss the following questions with the members of your group and then try to help us find the acceptable answers:
    a. Can you weigh or measure life? Explain.
    b. What do we mean by the everyday phrase, "SHE'S FULL OF LIFE?"
    c. Can you have more or less of life?
    d. Can we describe someone as being a quarter dead or two-thirds dead?
9. Re-examine your new definition of life and see whether or not you want to make any additional changes or modifications. If yes, please rewrite your definition. In addition, list all the characteristics that you decided to use to distinguish living from non-living organisms.
10. Again, is your modified definition of life "Functional," "Structural," "Conceptual," a combination of the two or three definitions," or "None of the above?" Explain.
11. What are the differences and the similarities between the characteristics of life and the characteristics of living organisms on the planet earth?
12. If you are an extraterrestrial being traveling in space and looking at the planet earth, what signs do you look for to indicate the presence of life on the planet earth? Explain.
13. If you have to write a letter to NASA astrobiologists to advise them what to look for in its search for life on other planets, what would you write?
14. Write at least two paragraphs explaining what you have learned from being actively engaged in this activity.

Warm-Up Activity 2: How well do you know your surrounding community?

In this activity, students are first asked to work individually to complete the missing information in columns 3, 4, and 5 of table 2 below. Upon completion, they are asked to engage in an open class discussion about their findings. At the end, ask the students to answer the following questions:

1. Which areas were the most difficult for you to select proper answers?
2. Which areas were the most difficult for the whole class to select proper answers?
3. Which areas were very easy for you to select the proper answers?
4. Which areas were very easy for the whole class to select proper answers?
5. Write at least two paragraphs explaining what you have learned from being actively engaged in this activity.

Table 2: Knowing your surrounding community

	Area	Define the area	Name the practitioner of this area	Knowing personally someone from this field in your 0wn Neighborhood
1	Anthropology			
2	Archaeology			
3	Astronomy & Space Scientists			
4	Astrobiology			
5	Botany			
6	Buddhism			
7	Chemistry			
8	Christianity			
9	Cosmology			
10	Economy			
11	Evolution			
12	Genetics			
13	Geography			
14	Geology / Earth Science			
15	Hinduism			
16	Judaism			
17	Microbiology			
18	Molecular Biology			
19	Islam			
20	Paleontology			
21	Philosophy			
22	Physics			
23	Physiology			
24	Political Science			
25	Religion			
26	Science			
27	Social Science			
28	Zoology			

Our experience in conducting this activity shows that many students encounter difficulty completing the columns on their own and thus move around to ask their classmates for the missing information. This type of collaborative learning creates the environment where students get to know each other better and gain the knowledge and information they are lacking by asking and discussion.

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