

**THE “ASTROSOCIOLOGY IN THE CLASSROOM” PROGRAM:
INCORPORATING THE SOCIAL SCIENCES FOR SUSTAINABLE
MARTIAN SETTLEMENTS¹**

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¹ This essay is an added item from this author for the 25th Annual International Mars Society Convention (2022) that expands and revises the contents of the slide presentation.

ABSTRACT. The Astrosociology Research Institute (ARI) was founded by this author in order to help facilitate and contribute to the development of astrosociology, which is defined as the study of astrosocial phenomena (i.e., the social, cultural, and behavioral patterns related to outer space). As astrosociology is a multidisciplinary academic field that focuses on issues related to the human dimension, it is important to address what the social and behavioral sciences, humanities, and arts can contribute to the impact of outer space on humankind, both on Earth and beyond. A fundamental facet of ARI's approach is the expansion of the "Astrosociology in the Classroom" program, which is underway in southern California among high school students, Harvard University students, and also expanding soon among students currently ranging from first grade to the post-secondary level. A fundamental objective here is to propose research hypotheses that are designed to stimulate thought especially among students regarding future astrosociological avenues of education and research. Such exercises in the classroom will initiate interactions that can achieve unprecedented results related to settling on Mars and in other space environments. Specifically, this essay focuses on discussions related to achieving a sustainable Mars settlement that must involve both branches of science, which are related to each of the hypotheses.

INTRODUCTION

I don't think the human race will survive the next thousand years, unless we spread into space.
- Stephen Hawking

Although it is not currently unknown when a potential human extinction event may threaten Earth with no way to mitigate the damage, it is inevitable unless space settlements become common. Unfortunately, humans are not yet ready to permanently settle beyond Earth. Nevertheless, planning for Martian settlements from all perspectives is critical, which includes the physical and natural sciences as well as astrosociology. It is therefore important to consider each potential problem, both physical and social, before sending a high number of humans into space on a long-term or permanent basis. Moreover, the interactions between the physical and social dimensions mandate formal collaborations between the two, as complications for sustainability will exist.

Early human activities on the Martian surface will likely include crews of three to six individuals.ⁱ This will not continue over time. Once a permanent location becomes established, the numbers will increase rather substantially for a period of time. This essay focuses on planning for this later stage of growth when a human population attempts to establish a permanent settlement. Planning for his larger population will require much more thought. At this stage, settlers remain on Mars and engage in constructing a functional, long-lasting community. Whether it can expand into a stable space society is the focus here. Presentation of some important areas of astrosociological concerns that can spark student and educator interest represents the purpose of this exercise.

Astrosociology exists in order to change the status quo that is necessary to better understand the relationship between outer space and humankind. The relationship between humankind and space from a social-scientific perspective has been studied over several decades although this approach remains underemphasized compared to approaches based on the physical and natural sciences, technology, engineering, and mathematics (i.e., STEM).^{ii,iii} Continued success depends on educators accepting the very existence of astrosociology and presenting it to their students in the

classroom, which is further important for the successful continuation of space exploration and settlement into the future. Acknowledgment that an academic field exists that interjects a greater level of attention on social-scientific analysis into the issues related to outer space is sorely needed. Additionally, it is important for students to encourage their classmates and educators to accept that this academic field exists and is worthy of pursuing in academia. Outside organizations must also contribute to ensure that the development of astrosociology continues.

Two related questions are important to consider. First, how can the social sciences contribute to the traditional space community in ways that outshine their past contributions throughout a space age up to this point in time? Second, how can the social sciences, humanities, and arts make a significant dent in a status quo devoted nearly exclusively to a focus on STEM-related issues? The answers to these questions are numerous and complex, and thus, this essay will focus on the presentation of the potential contributions of the social sciences and humanities. The focus here is on the educational ramifications associated with ARI's "Astrosociology in the Classroom" program that now also targets middle and high school students. Collaboration between the STEM disciplines and astrosociology remains a vital linkage between the physical and social realms that together will bolster an increase in the potential of space exploration, settlement, and utilization of space resources for the benefit of humankind.

An important aspect of this essay relates to what students need to learn, especially concepts that tend to be neglected altogether or at least downplayed whenever space studies are involved. The vital nature to expand a social-scientific focus and analysis represents a central theme underlying this presentation. Throughout this essay, research hypotheses emphasize many of the social-scientific issues that middle and high school students need to think about, including those who think of themselves as dedicated STEM-based learners. What should become evident is the fact that any narrow focus is untenable for the pre-planning, actual voyage, and early constructing of future settlements stages. It is important for younger students to be made aware that preparing and running a Martian settlement presents participants with never-before experienced complications. These discussions exist to demonstrate these complications so that students' imaginations are stimulated. Any expansion of one's perceptual limits represents a noble exercise.

Research hypotheses offered here are generalized predictions. They are statements about expected relationships among concepts. Later statistical analyses during future studies will require a shift from the conceptualization level to the operationalization level of analysis, meaning that general concepts need to be converted to specific variables that can be measured much more precisely. At this early stage of astrosociological research being taken much more seriously by high school students, conceptualizations are important due to the obvious fact that no space settlements yet exist. Nevertheless, it is important, even crucial, to think about important relationships regarding what social science can contribute to help ensure that settlements beyond Earth can be constructed in ways that better ensure their success over time. The bottom line here is that sustainability is a key concept and thus the dependent variable for most of the hypotheses that follow.

In the meantime, analog space missions and historical terrestrial expeditions already provide pre-settlement research opportunities. Both educators and especially students can accomplish a great deal of astrosociological analysis through the study of early concepts related to these and other research hypotheses. Later sections provide hypotheses and related discussions for students to

think about that can expand astrosociological education and research into the future. Although no Martian settlements yet exist, it is by no means too early to better understand what astrosociology can contribute to increase the likelihood that settlements will become sustainable. Otherwise, chaos and instability will reign when settlers arrive on Mars and their stay beyond that point.

THE CENTRAL HYPOTHESIS

Research Hypothesis: The greater the input from the social and behavioral sciences, humanities, and arts, the greater likelihood that a Mars settlement (or any other one elsewhere) will prove to be more sustainable. This central hypothesis predicts that a greater level of social-scientific input will be more beneficial than the currently most often advanced traditional approaches alone that focus almost exclusively on non-social-scientific analyses. The dependent variable is a conceptualization of the level of settlement sustainability. Independent variables involve social-scientific attention to the social life in the settlement that can include social cohesion, mental illness, construction of institutions and groups, and the development of a dominant culture. This is a positive relationship predicting that when one concept (greater social science input) increases the other concept (level of sustainability) also increases. Monitoring of positive and negative forces that can produce positively functional outcomes or result in social problems must involve an ongoing assessment among the social scientists in the settlement.

This hypothesis represents a fundamental aspect of the astrosociological approach regarding space settlements. It predicts that the STEM disciplines alone cannot assure a sustainable settlement and so concepts associated with STEM-related effects can serve as a control group. While input from the STEM-related disciplines and fields that fall under physical and natural sciences are necessary, they are not sufficient to ensure a sustainable population alone. Input and interactions between the social and physical branches of science are absolutely crucial to construct and maintain a sustainable and livable Mars settlement in a never-ending process in which social change is often unpredictable, especially when surrounded by an atmosphere that is unbreathable and a location that is isolated from the bulk of humankind. The central hypothesis emphasizes the need for the social sciences to be included rather than somehow diminishing the input of the physical and natural sciences. STEM and the social sciences can both benefit from their integration.^{iv}

In this case, defining the characteristics of a successfully stable settlement related to physical requirements on the one hand is vital. On the other hand, deciding what types of social-scientific concepts contribute most to an enduring settlement will require a historical analysis of terrestrial settlements in concert with unique conditions existing in extraterrestrial environments. From there, unique social-scientific research from within the settlement will prove absolutely essential. Over time, settlements with different characteristics on Mars and elsewhere can be compared to get a greater handle on what types of social-scientific characteristics are more or less beneficial to long-term survival for settlers so that all those in other settlements can benefit.

THE ASTROSOCIOLOGICAL FRONTIER

It has been quite apparent through the years that social-scientific research and education related to outer space lacked a meaningful social-scientific component. Thus, when astrosociology was publicly introduced by this author in 2004, an *astrosociological frontier* was automatically created

at the same moment. It remains largely unexplored meaning that social-scientific education and research remains relatively absent compared to the presence of STEM-related disciplines, which is quite an understatement. The definition follows.

“The ‘astrosociological frontier’ represents an analogous framework to that of space as the ‘final frontier,’ as both territories are quite empty of human activity and ripe for exploration. ... This focus on the astrosociological frontier provides insights about the need for a social-scientific field to place the human dimension in its proper place alongside familiar space community concerns such as engineering”.^v

The concept of this academic wasteland emphasizes to students that educators generally continue failing to include lessons associated with astrosociology in social science and social studies classrooms as well as STEM-related classrooms, which can be understood as a social problem.

Pioneers on the astrosociological frontier have increased in number quite recently, as will be discussed later in this essay. They include college students, but now they also consist of high school



students and the recent addition of those in middle school. The needed introduction of missing astrosociological materials in classrooms is vital as stated in the research hypothesis below. This will become more obvious when considering the various arguments associated with the

“Astrosociology in the Classroom” program and the “First Classroom on Mars.” Movement toward greater settlement of this under-focused frontier of study is consequently underway in earnest.

Research hypothesis: Settling the astrosociological frontier on Earth is a vital pre-mission condition for constructing a sustainable and livable space settlement. The independent variable consists of the concept of the astrosociological frontier being settled to a reasonable extent. It is important to operationalize the characteristics of the astrosociological frontier including the threshold of what constitutes a reasonable level of acceptable presence of astrosociology in academia. This concept may be difficult to achieve, as STEM-heavy plans are already underway that will not allow for astrosociology to become mainstream enough. The dependent variable again characterizes a sustainable and livable settlement once it is constructed and populated. Therefore, it is important to conceptually settle Mars on Earth although testing this hypothesis directly will be impossible until an extraterrestrial settlement actually exists.

For students, the focus should be on defining the astrosociological frontier and how well it is settled over time. Exploring elements of a sustainable settlement is important, as are theoretical exercises regarding how this hypothesis may be studied. Additionally, role playing games can enlighten students about the difficulties of constructing and running a space settlement over time in the classroom. Such exercises can expose limits in relying too much on physical science without the input of social science.

On the theoretical level, astrosociological education must expand to a significant degree in educational institutions at all levels of education. Again, the astrosociological frontier must be

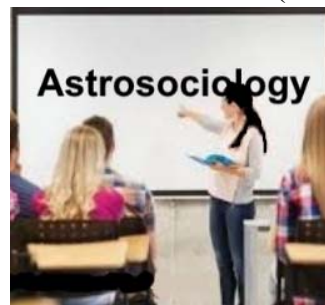
much more settled here on Earth before the settlement of Mars can be settled sustainably. Because space-related education and research in the social sciences and humanities currently do not exist to the extent that they do among the STEM disciplines, a much greater balance is required. Collaboration among the physical and social sciences regarding the importance of astrosociology must occur, otherwise getting to Mars may be much simpler than sustaining a population there over time. Thinking about the lack of astrosociology provides students with the ability to recognize the social problems that may well occur.

Pre-mission planning and travel within the spacecraft on the way to Mars require social structure just as settlements must exhibit on Mars. In fact, the voyage itself actually involves the cultural and social structural elements that were hopefully pre-designed on Earth. Putting planning into practice while on the way to their destination is vital. Sustainability may not even exist on the way to Mars without a stable overall social structure. It is unwise and likely the prelude to chaos without such preparation. Thus, such a scenario is highly unlikely without a substantial settlement of the astrosociological frontier well before launch according to this hypothesis.

In conclusion, then, the astrosociological frontier must be settled to a great enough extent before settling Mars or anywhere else is possible on a sustainable and livable basis. Otherwise, too few astrosociologists and therefore too little astrosociological knowledge will exist. As the hypothesis predicts, this state of affairs will depend to a substantial extent on how much the physical science and other STEM sources of knowledge can integrate the social sciences, humanities, and arts. In contrast, the hypothesis predicts that the status quo will not be adequate enough to best ensure that a sustainable settlement is probable due to the great imbalance between physical and social scientific input. For students, debating about how much social science will be necessary to reach an acceptable balance represents an important area of discussion and study.

THE “ASTROSOCIOLOGY IN THE CLASSROOM” PROGRAM

Settling the astrosociological frontier involves both instructing students and getting educators to teach them about the social-scientific issues related to replicating a social system on another planet. Moving astrosociology into classrooms allows for the cultural, social, and behavioral factors (i.e., astrosocial phenomena) to be integrated with the physical and natural sciences for a much more holistic approach to understanding what is important for establishing a stable space settlement. Students should keep in mind that a sustainable space settlement is more complex than commonly thought by the space community,^{vi} which is reflected by its indifference to social science.



Building the physical structures is essential for survival of settlers. However, the settlers inside of the physical structures require organization and social rules that regulate their behavior on an ongoing basis. Additionally, social structures require construction including the political and economic systems, criminal justice system, the shared larger culture, and interplanetary relations with Earth entities. Members of the population must fill multiple and diverse statuses, each with their own roles. Moreover, the complexity will increase as the population grows. These types of complications make the following hypothesis important to the development of astrosociology.

Research hypothesis: The more that young students as early as the elementary school level are taught about astrosociology (that includes the social and behavioral sciences, humanities, and arts as they relate to space), the more they can contribute to the construction of a truly sustainable settlement through planning or when they actually arrive at Mars. More simply stated, this hypothesis predicts that students who have studied astrosociology will be more likely to participate in the construction of a stable settlement. This is because those who finally settle Mars and other space environments will be more adept at understanding how the physical *and* social sciences must coordinate and collaborate than those not exposed to astrosociology.

Once again, the dependent variable is conceptualized as the level of sustainability of the settlement. Three types of independent variables are possible: the level of exposure of astrosociology education for (1) elementary school students, (2) middle school students, and (3) high school students. (This does not include college or beyond). This hypothesis assumes that research will be conducted both on Earth as in analog environments and when settlers, young students who complete their education, finally arrive at the settlement on Mars. The independent variables allow for a comparison among the three types of students at their educational levels as they relate to the dependent variable. Furthermore, they can be studied independently or in combination. What proportion of the analog astronauts and settlers on Mars are exposed to astrosociology are vital concepts that need to be measured at the operationalization stage. When operationalized, the dependent variable can include various conceptualizations that determine how well social-scientific issues are understood compared to physical ones.



The figure to the left is meant to display an empty astrosociology classroom as a representation of the very few ones that currently exist. The distortion effect signifies the still low acceptance level in academia. Thus, the hypothesis above refers to situations in which the astrosociological frontier become more settled, hopefully before the settlement of Mars. This points to the importance of expanding the “Astrosociology in the

Classroom” program to levels much greater than experienced today. This beginning, however, must occur in order to encourage greater expansion so that the STEM disciplines and social sciences can interact much more formally and interdependently. Otherwise, the status quo will continue to stymie the development of astrosociology and related academic fields.

Again, STEM, which includes the physical and natural sciences is necessary to create a successful and sustainable settlement although it is not sufficient to do so without the social and behavioral sciences as well as humanities. Both branches of science, the physical and social, are required in a formal collaborative relationship to make this possible as a long-term enterprise. This becomes possible when astrosociology becomes much more common in the classroom, especially within social science and social studies classrooms.

In conclusion, it is important to keep in mind that a major aspect of the “Astrosociology in the Classroom” program revolves around the tenet that students must be the driving force in the future of astrosociology’s development. They need to bring everyone else interested in space exploration

and settlement along with them. While educators and professionals in the space community must also play their parts in its development, students will carry the development of astrosociology into the future. Students should heed a central message, which emphasizes the fact that the status quo will become increasingly untenable over time, even as the public and others have doubts.^{vii,viii,ix} It is vital to keep these contradictory opinions in mind, including how they affect future development.

THE “FIRST CLASSROOM ON MARS”

A vital part of the “Astrosociology in the Classroom” program involves the partnership between ARI the Barboza Space Center (BSC) that was initiated in 2021. A major impact of this cooperative project relates to a formal interaction between the STEM and social science disciplines.

“Conceptually, ...[the First School on Mars] program creates a simulation in which high school students work on projects that are relevant to the tasks necessary to sustain a Mars settlement. The ‘first’ aspect of the title refers to the idea that lessons need to be learned on Earth before the attempt of actually settling Mars ever takes place. The first classrooms are preparatory initiatives that introduce students to key concepts related to settling Mars.”
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The “First Classroom on Mars” and the “Astrosociology in the Classroom” have united to form something brand new. Something that has accelerated the development of astrosociology.

Thus, a transformative change occurred when the Barboza Space Center and the Astrosociology Research Institute partnered together to create Tiger Teams² that place the student in each team taking the status of astrosociologist. Each team of ten students includes those who work as STEM scientists while others work as social scientists. Moreover, the student acting as astrosociologist poses as the leader, which means that everyone is introduced to how the social sciences can integrate with the physical and natural sciences, engineering, technology, and mathematics. This approach is a totally new approach to teaching about the important issues that relate to settling Mars.

Research hypothesis: Placing the student assigned as the astrosociologist who leads the Tiger Team provides that team with a better understanding of space settlement issues than a team that includes students only studying STEM-related subjects without the astrosociologist as a member of the team. Comparing how things worked before the astrosociologist was added to the newly formed teams is the key idea here. This hypothesis relates to the underlying assumption that Tiger Teams that consist of students who contribute both physical and social knowledge can produce much more holistic results than simply relying on the physical sciences. It calls for the comparison between two teams, either both that exist at the same time or one team previously existing and the other recently established. Testing terrestrial analogs to teams later established in a real classroom on Mars can also provide interesting results. How well the analog missions



² For more details regarding the definition and relevance of Tiger Teams, see note ii, p. 8.

address astrosociological issues represents an important focus for the present-day because their existence represents the best way to simulate the issues that may exert themselves in a Mars settlement once humans set foot there.

Any sustainable settlement on Mars or elsewhere requires priming the astrosociological pipeline with trained students at all levels of education who possess backgrounds from both the STEM disciplines and the social sciences. This is a comparative hypothesis contrasts conceptualizations associated with levels of social-scientific knowledge among (student and/or actual) settlers in each type of Tiger Team. It predicts that teams that include astrosociologists as leaders increase the odds of more holistic knowledge and thus a greater likelihood of a long-term successful settlement.

This hypothesis calls for students to dig deep and utilize their *astrosociological imaginations* in order to grasp their insights about what the STEM disciplines alone cannot address and contrarily what the social sciences can contribute in order to gain a more comprehensive understanding of the impact of outer space on the contemporary lives and futures of humans wherever they may exist. Utilization of one's astrosociological imagination requires a high level of acceptance and dedication to the development of astrosociology. Without it, social science remains insignificant.

“The astrosociological imagination is a high-level conceptualization; it is an insightful way at looking at the world that allows a person possessing and exercising it to make connections between his or her personal world of experiences and the macro-level (larger scale) existence of astrosocial forces. These individuals possess the ability to separate personal biography from larger world events – in this case, astrosocial phenomena – and understand their interconnections.”^{xi}

Students will be able to access their astrosociological imaginations over time once they become exposed to astrosociology education and research.

At the moment, students at higher levels than elementary school will need to be made aware of astrosociology, but priming the pipeline at lower levels will eventually allow students to move up and gain greater sophisticated knowledge. Making students aware of astrosociology at all levels of education is a priority because the social sciences and humanities remain far behind the physical and natural sciences as well as the other STEM disciplines within both the space community and the astrosociological frontier generally. Lacking the astrosociological imagination is status quo.

A FEW MAJOR ASTROSOCIOLOGICAL SUBFIELDS

While a few of the various existing subfields are discussed here, the continuing development of astrosociology will result in additional breakdowns derived from the overall basic definition. They will be created due to the specific interests of astrosociologists who join the movement to focus on astrosocial phenomena. This becomes inevitable as the astrosociological frontier continues to be settled in terms of a growing number of educational institutions and educators that decide to participate in the “Astrosociology in the Classroom” program. Specific newly concentrated upon facets of astrosociology will become studied more in depth as new subfields become established.

For now, the number of subfields currently explored is limited to four (i.e., medical astrosociology, exo-astrosociology, the astrosociology of law, and applied astrosociology), as discussed below. Compared to sustainability, additional independent variables will relate to new subfields covering

such areas of social life as education, family, the economy, politics, and cultures and subcultures. Social systems are extremely complex and social change alters a variety of their parts as time passes. It is therefore essential that social-scientific education and research continues to study and help explain what is taking place, including manifesting positive and negative forces because they continually evolve producing ever-changing social conditions.

Each of the subfield sections present research hypotheses that only scratch the surface of what types of research are possible. Again, they represent a starting point for students and others from which to expand their explorations that are also relevant to these subfields and others that they formulate in the future. These hypotheses exist to stimulate thought, especially among students, about what research they want to perform that is in line with their interests.

Research hypothesis: As astrosociology grows in terms of the number of students, educators, and professionals who accept it, astrosociologists will develop additional subfields, and this it will assist in the growing development of this academic field. Increasing development of astrosociology serves as the dependent variable. Dependent variables will consist of conceptualizations related to how well or poorly the field is developing, and relatedly, to the level of increase of subfields. Conceptualizations regarding the number of those participating in astrosociology education and research represent independent variables.

Will the prediction of the central hypothesis that greater participation by non-STEM individuals increase the likelihood of greater sustainability of a Martian settlement become a reality; and moreover, will this result in an increase of the number of subfields? As seen by sociology, anthropology, psychology, and other disciplines, subfields are important because they allow researchers to concentrate on specific areas such as deviance, politics, economics, or family that still fall in line with the overall scope of the discipline. The multidisciplinary nature of astrosociology provides opportunities for more researchers to interact and coordinate their efforts. The isolation of the social sciences as inconsequential science applies less and less as students are introduced to the merits of combining the two branches of science.

Medical Astrosociology

Medical sociology provides a good subfield as a model. There are already precedents for this type of subfield in sociology and anthropology that traditionally focus on terrestrial concerns. However, the same types of concerns will inevitably occur in addition to unprecedented occurrences never experienced on Earth. Medical sociology can serve as a good example.

“Medical sociology can be defined as the scientific study of the social patterning of health. In this case, it is a study of how social factors (e.g., class, race, gender, religion, ethnicity, kinship network, marriage, educational status, age, place, and cultural practices) influence human health.”^{xii}

“Medical astrosociology [is] defined as the study of [behavioral,] social and cultural patterns (i.e., astrosocial phenomena) that affect medical issues in space environments... [It is] an approach that combines issues related to space medicine with social-scientific concerns. It may be termed “the space variant of medical sociology” because it borrows concepts primarily related to...[sociological, psychological, and anthropological] impacts

on medicine and medical practice. It combines space medicine and a social-scientific approach in many ways, many of which currently remain beyond our knowledge.”^{xiii}

The unknown predictability of astrosocial forces makes it imperative for medical practitioners in the settlement to take into account what patients and their close contacts such as family members want in addition to medical practitioners’ concerns based on treating injuries and saving lives. Sometimes potential death is selected as an option by patients because doctors’ suggested drug use or other types treatments are rejected.^{xiv} Social and cultural differences matter wherever physicians and patients interact based on religion, social class, and other factors that include inequality.

Medical sociology focuses on how health and disease are defined by various categories and individuals as well as how they perceive whether or not particular treatments are acceptable. Medical practice is carried out in ways that extend beyond the principles related to traditional attempts to cure the sick or treat injuries. Illnesses and other medical complications can be viewed as social problems when sociocultural complications arise. Ethical issues can become either favorable to medical practice or hinder it. Sociocultural conditions can contribute to illness, or they can prevent them. Thus, norms and values associated with medicine will differ within a society.

Many of the social factors referred to above will be familiar to researchers beyond Earth because the early generations of settlers will have been socialized in terrestrial societies. Beyond this reality, the harsh environment and isolated nature of the settlement will provide additional challenges never experienced on Earth.^{xv} However, while social life can result in commonly experienced social problems familiar in terrestrial societies, new ones will also be produced on Mars that will require different solutions and practices. The harshness of the Martian environment will produce social forces not ever experienced on Earth. Medical challenges (and other types) will result in the need to cope with unprecedented events including life threatening and ethical conundrums.^{xvi} Nothing comparable to these environmental characteristics exist on Earth.

Research hypothesis: Medical procedures, practices, treatments, and approaches to illness and injury that become inadequate without acceptable consideration of social and cultural forces could then become exasperated in an isolated and enclosed Mars settlement and in turn can decrease the likelihood of sustainability. This hypothesis generally predicts that settlement sustainability can be threatened if too little attention is paid to patients’ wishes or medical inequalities, as examples. Concepts related to inadequate consideration of sociocultural and psychological forces serve as the independent variable here.

The positive relationship inferred by this hypothesis predicts that when social science is ignored, then sustainability is threatened because terrestrial medicine may be similar to Martian medicine, but the two will quickly diverge from one another the longer humans live in settlements. New ways of practice will need to emerge. Coping successfully with newly produced social problems related to medicine will depend on a broad approach, characterized by physical *and* social science.

Social conditions that characterize the overall status of the medical sector exist as a balance between the overall positive and negative set of conditions that characterize the settlement. The bottom line here revolves around how the sociocultural and medical forces combine in a particular settlement. Resisting or ignoring these former forces will potentially impact negatively on the latter forces. Thus, medical astrosociology represents an extremely important subfield for students,

educators, and practitioners to take seriously. For students especially, this subfield is largely unexplored and a rewarding one for medical astrosociology pioneers to pursue. In any case, studying medical astrosociology within Tiger Teams or as individuals contributes to the needed development of astrosociology.

The Astrosociology of Law

While all subfields that will emerge cannot be included here, it remains an easy prediction that the social institutions that will need to be constructed in a space society once the population grows large enough will become targets for study and research. Examples include family, economy, politics, military, and religion. Prejudice, discrimination, inequality, social stratification and other issues that can involve legal ramifications will also be important to monitor closely. Here, the astrosociology of law is explored.

Once again, it is useful to use the sociology discipline to begin this discussion. Following the definition of the sociology of law, it will be expanded to apply to space settlements. It is important to keep in mind that terrestrial legal systems have important implications for space settlements. At the same time, every application of law may not apply or must be updated. New laws that do not exist on Earth will be required.

The following is a common definition of the sociology of law, which is the cornerstone of any system found in democratic societies.

“The sociology of law, or *legal sociology*, is an academic specialty within the general discipline of sociology that attempts to theoretically make sense of, and explain, the relationship between law and society, the social organization of the legal institution (order or system), the social interactions of all who come in contact with the legal institution and its representatives (police officers, lawyers, judges, legislators, etc.), and the meaning that people give to their legal reality. The sociology of law is not a self-contained knowledge field. It shares much intellectual common ground with jurisprudence, criminology, the anthropology of law, the sociology of deviance, political sociology, and other kindred areas.”^{xvii}

In any society, whether on Earth or Mars, law has, or will have, an impact that transcends all aspects of any society. Thus, for those interested in planning and constructing space settlements, it is vital for them to think about social institutions including their design and impact on the social lives of settlers. Legal concerns are central because deviance is a cultural universal.

Research hypothesis: If a formal and legitimate legal system is not constructed or is somehow inadequate, then deviant behaviors will rise to a level at which a space settlement will become unsustainable. When the legal system is inadequate, then settlement stability is threatened according to this positive relationship. The dependent variable includes increased deviance and sustainability according to this hypothetical prediction. The concepts related to the level of legitimacy of the legal system comprise the independent variables. They can include systems that favor elites and autocrats, consist of laws that fail to address deviance and social problems, and those that simply remain unconstructed. Dependent types of variables that include the levels of crime, other types of deviance, and social problems will be produced that will threaten the successful longevity of the settlement. A criminal justice system must be capable of dealing with

the various forms of disruptions to social life that will inevitably occur. Application of the law will increasingly become more complex as the settlement population increases. Nevertheless, officials must remain watchful in order to cope with deviant acts at any stage of settlement development.

The astrosociology of law is tied to the space society. It involves the same characteristics that defines the sociology of law, but it adds the fact that unique forms of potential deviance and social problems associated exclusively to placing a growing population on the surface of Mars are likely to exist. Due to the hardships involved in maintaining the physical habitat structures, they may well lead to health and safety violations, which consist of various forms of deviance.^{xviii} Pressures to cut corners related to conducting proper maintenance procedures can result from a number of other problems that can even threaten the structural integrity of habitats; but whatever occurs, they will require applications of the law regardless of why they originate. Such actions can result in policy disagreements and conflict.

According to the United Nations Office for Outer Space Affairs (UNOOSA):

“...space law can be described as the body of law governing space-related activities. Space law, much like general international law, comprises a variety of international agreements, treaties, conventions, and United Nations General Assembly resolutions as well as rules and regulations of international organizations.”^{xix}

In contrast, the astrosociology of law focuses on (1) the implications and ramifications of the effects of space law on terrestrial societies and (2) the application of laws and reactions by related social structures in extraterrestrial social systems. This particular essay focuses on the second aspect, as the future establishment of a Mars settlement will need to construct a criminal justice system and related legal structure.

What will it look like? Will it be a near replication of a terrestrial society’s system, a combination of new and existing elements, or something totally new and unprecedented? Such a focus on the establishment of a legal system and how it functions over time represents under the purview of astrosociology. The hypothesis above emphasizes the importance of instituting a legal system of some type because it has implications for the sustainability of the settlement over time. Of course, a system run by autocrats may not remain stable over time. Thus, it is vital for astrosociologists to study such issues in a Mars settlement once planning for its overall structure begins to occur.

Exo-Astrosociology

It must be made clear that it does not matter whether or not extraterrestrial life is detected at any particular point in history because the very search itself focuses on a very fundamental question to humankind; namely, is humankind alone in our universe? This is a question that propels the Search for Extraterrestrial Intelligence (SETI) and astrobiology forward. Indeed, the very search itself for a second genesis of life involves implications for human societies and their populations. In a sense, it does not matter whether or not humans discover extraterrestrial life because the constant feeling of loneliness drives the continuing search. Humankind can never be assured that extraterrestrial life exists unless such a discovery is confirmed.

Research hypothesis: The search for extraterrestrial life is a key component for favoring the advancement of space exploration that includes an important determinate to settle on Mars

and elsewhere. The dependent variable involves the drive to explore space and settle away from Earth while the independent variable consists of measures related to the level of importance related to the search for extraterrestrial life. Especially for Mars, where the search for life there has driven a substantial percentage of funding for U.S. space exploration, perceptions about the importance of conducting the search by Martian settlers and the ability to do so by officials allocating resources are important for sustainability.

However, the search can serve as a unifying force or one that creates disunity among those in the population. This is a positive relationship in the sense that when the determination to search for extraterrestrial life is high, then the determination to settle Mars is also higher. Part of this prediction involves the idea that those who spend their lives studying the potential to discover extraterrestrial life will continue to advocate searching for life on Mars that result in new missions devoted to it.

What does exo-astrosociology add to the STEM-based approaches to discover extraterrestrial life? How is it different from the traditional approaches? First, a definition is important and then an argument regarding why a third approach beyond astrobiology and SETI is desperately needed.

“The subfield of exo-astrosociology is defined as the study of extraterrestrially-related forms of astrosocial phenomena (i.e., social, cultural, and behavioral patterns related to extraterrestrial life in outer space)...It involves how ongoing failure and potential eventual success affects societies, cultures, social groups, subcultures, and individuals.”^{xx}

This definition adds another area of study in social studies and social science classrooms, which is long overdue.

Increasing the focus on issues related to the social sciences and humanities provides an important modification to the status quo, but more importantly, it provides increased collaboration among those in the two branches of science. For astrosociologists, it is important to recognize that SETI and astrobiology have not carried out their investigations totally without the input of the social sciences.³ Nevertheless, the social sciences expand the scope of study related to how the search for alien life occurs and how social groups will react following such a discovery. Even how the announcement will be organized falls under the purview of social science inquiry. Different social groups favor varying approaches, which still require debate to reach an agreed-upon methodology.

This third approach to the study of how humans organize themselves and carry out the search to discover extraterrestrial life differs from SETI and astrobiology. Because the focus on astrosocial phenomena complements the traditional approaches, the social sciences add the dimension of a dedicated human focus onto the technical, natural science, and physical science orientation. In Martian settlements, exo-astrosociology provides scientific coverage regarding how and why the search for alien life is carried out. This includes coordinating with the other scientific approaches that may not favor searching for alien life as a top priority.

³ See, for example, the following report: Harrison, Albert A., and Connell, Kathleen (eds.) (1999). *Workshop on the Societal Implications of Astrobiology: Final Report*. Ames Research Center: NASA Technical Memorandum. (Final Report revised on 01/20/2001). A copy is available in the ARI Virtual Library: <http://www.astrosociology.org/Library/PDF/NASA-Workshop-Report-Societal-Implications-of-Astrobiology.pdf>

Applied Astrosociology

Astrosociology focuses on the human dimension both in space *and* within terrestrial societies, as there is a two-way relationship between outer space and Earth. As a comparison, applied sociology is “...using the sociological tools to “understand, intervene, or enhance human social life.”^{xxi} Applied anthropology^{xxii} and applied psychology^{xxiii} also aim to solve personal and social problems.

Similarly, applied astrosociology is defined as “...the application of astrosociological knowledge to astrosocial phenomena in a manner consistent with improving them for the betterment of (1) space exploration and potentially (2) other aspects of a particular society.

In other words, applied astrosociology involves the use of theory and research to solve real social problems related in some way to astrosocial phenomena.”^{xxiv}

The insights and discoveries yielded from space research have been applied to the mitigation of social problems faced by terrestrial societies. Moreover, these insights and discoveries have also produced solutions to problems that were unrecognized before their introduction. Cultural influences such as science fiction, taking Star Trek and War of the Worlds as examples, have led to the cellphone, rocket, taser, and other products and services.^{xxv}

While social, cultural, and behavioral patterns impact on societies wherever they may exist, they are also subject to manipulation or efforts to transform negative patterns into positive ones. Applied astrosociologists will have the obligation to call attention to, and even intervene in, efforts to instill positive social change. They study astrosocial phenomena and seek to implement changes that mitigate social and practical problems by providing new or updated solutions. Practically speaking, their efforts are difficult to implement due to forces related to economic, political, and other types of institutional and other types of interference.

Research hypothesis: The more that applied astrosociology strategies are successfully utilized to address social problems in a particular space settlement, the greater likelihood that settlement sustainability will exist. Independent variables consist of concepts related to the level of how effectively efforts are applied to the implementation of reducing social problems. Independent variables include the conceptualizing strategies utilized to address social problems. This hypothesis represents a positive relationship in that when successful strategies are implemented, then social problems decrease resulting in a greater level of sustainability. The successful long-term existence of a Mars settlement is due in part to the minimized impact of social problems, which means that they must be recognized and understood.

Knowledge gained via trial-and-error efforts accumulated during humankind’s residence on Earth can provide applications to the construction and maintenance of a thriving Mars settlement. Conversely, lessons that originate in space settlements can also theoretically be applied in terrestrial societies. Because difficulties on Mars will produce social forces that make life increasingly challenging, solutions can be applied to the greatest social problems faced on Earth.

Thus, astrosociologists can affect social problems by conducting research, advising politicians and others, and intervening themselves in various ways. Deviance, mental illness, and other types of social problems have proven universal realities in terrestrial societies. Settlement sustainability will depend in large part on whether or not serious disruptions remain unproblematic over the

course of the settlement's existence. Astrosociologists can help understand these types of trends. Students can study social problems on Earth and learn how mitigations against them can be applied in space settlements in the future. Imagining what problems may occur on Mars can result in solutions germane to the social sciences, which represents an important exercise for students and teaching opportunities for educators.

AN ASTROSOCIOLOGY COMMUNITY

For our purposes, a community is defined as a social unit consisting of individuals who share a common interest. In this case, it is astrosociology. Beginning on Earth, it is important for a growing number of social scientists to consider themselves as astrosociologists, which can only occur on a significant level through astrosociological education. The key resides in collaboration among interested parties in the social and behavioral sciences, humanities, and arts working together. Minimization of addressing astrosociological issues will prove antithetical to the establishment of an astrosociological community.

Traditionally, social scientists interested in space issues find themselves isolated within their discipline such as sociology or anthropology and the same has existed within their own departments and programs. Building an astrosociology community can put an end to this status quo by connecting astrosociology students, educators, and professionals in diverse locations. Efforts associated with the "Astrosociology in the Classroom" program can help to unite all three categories of individuals moving forward so as to build the community.

Research hypothesis: Construction of a sustainable space settlement will depend in large measure on the growth of the astrosociology community. The dependent variable is the construction of a sustainable space settlement. Independent variables include concepts associated with the growth of the astrosociological community in the United States and across the world. This hypothesis clearly assumes that much work including preplanning must occur long before humans are sent to Mars for temporary missions and especially for the construction of permanent settlements. The latter types of situations will prove much more difficult to sustain partly because of the hardships incurred in setting up a permanent settlement in the first place and the partly due to the distance to Earth that involves delayed assistance.

The need to preplan the basics needed to eventually construct a sustainable off-Earth settlement clearly indicates the need to introduce astrosociology to as many students as possible. It is vital to expose students to the combination of the physical and social sciences so that the dream of settling on Mars becomes feasible in the future. Students need to form the backbone of the astrosociology community. The focus on introducing students to the social sciences cannot be overemphasized, as student astrosociologists represent the missing component in the traditional space community.

FOCUS ON STUDENTS

The multidisciplinary nature of astrosociology means that a diversity of students with different interests and backgrounds are essential to come together to develop this academic field. This must occur at all levels of analysis from the individual to the classroom to the department to the school. It must occur from the elementary school level through to the post-secondary level. The pipeline

consists of upward student movement overall, but contacts among individuals and groups with varying backgrounds and objectives are inevitable. While it can result in some disruptions, the overall benefits outweigh them, as diversity exists as a fact.

Because the flow occurs in all directions, students can be exposed to inspirational contacts that can include educators, family members, friends and colleagues, mentors, and anyone else who motivates them. Space studies can inspire students by its very nature, but the human dimension represents an essential source of motivation. Exposure to astrosociology provides an additional source of knowledge related to the human dimension of space exploration while it also brings in new contacts that students would otherwise miss contacting.

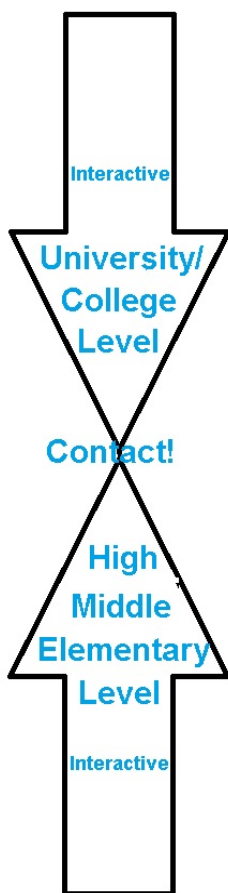
An astrosociology community must involve students and educators as a central focus, as emphasized throughout this essay. The “Astrosociology in the Classroom” program remains both a major part of the Astrosociology Research Institute’s nonprofit mission to develop astrosociology and is essential to the Barboza Space Center’s mission to place students assigned as astrosociologists in leadership positions on Tiger Teams. Thus, it is fundamental to their partnership to place students in a position that advances the development of astrosociology.

Moreover, students benefit from the integration of the social sciences and humanities with the STEM disciplines. This integration expands students’ astrosociological imaginations and thereby their realizations about how the social sciences and humanities can broaden their perspectives about how the physical and social dimensions interact. This can result in increased chances for space settlements to be constructed and maintained over time for a sustainable future. Social problems will inevitably manifest unless both perspectives are involved.

Research hypothesis: The increasing number of students exposed to astrosociology will result in the greatest likelihood that astrosociology will continue its development (and settle the astrosociological frontier). This positive relationship predicts that as the number of students who study astrosociology (the independent variable) increases, then the greater the development of this academic field (the dependent variable) due to the idea that students possess the greatest potential of leading the development of this field. Successful settlement of the astrosociological frontier would also have a positive impact on planning for a sustainable Martian settlement.

Moreover, it is likely that a growing number of students familiar with social-scientific concepts and how the social and physical elements of a settlement must integrate will also strongly help to develop changes focusing on insistence of a formal collaborations between astrosociology and the STEM disciplines. Nevertheless, it will depend on the students accepting astrosociology as an important field to study and pursuing in the job market. This is an important part of the educational process that needs to increase throughout academia.

Furthermore, focusing on students at all educational levels is a vital strategy although the elementary through high school educational levels are most important at this time in history. A substantial acceptance here provides a foundation. As time goes by, an upward movement can occur that results in astrosociology becoming better understood. Acceptance at the university level is eventually necessary at a high level so that the upward flow in the pipeline occurs. Filling the job market with astrosociologists represents a vital need for the future.



The “Contact!” between the lower and upper levels depicted in the figure to the left refers to the situation in which students bring their exposure to astrosociology to students in the upper classes. The interactions among students at different class levels promotes the development of astrosociology in a new way. There are interactions within levels depicted in each arrow although the contact point potentially provides the point at which students between high school and college interact the greatest and therefore most forcefully promote astrosociology to higher levels as a legitimate academic field. The development of astrosociology cannot continue without high student input combined with a dedicated effort by educators. This combined interest in studying and teaching astrosociology has finally begun.

Thus, this pipeline from the elementary school level to the post-secondary level and beyond to the job market is essential in the long term. In reality, it is already messier than that, as students at various levels are already being affected. Students interact with one another at all levels of academia, especially as astrosociology becomes increasingly ubiquitous, which even includes some professional scientists in STEM and social science combined. The combination of the “Astrosociology in the Classroom” and First Class on Mars programs are now working to integrate the physical and social sciences, which has already incentivized students to learn more about the astrosociology and educational institutions to acknowledge this

movement as important. More schools are joining high school programs.

FINAL THOUGHTS AND CONCLUSIONS

As made evident in this essay, a high number of factors will contribute to both the sustainability of a particular space settlement and to its potential downfall. Inevitably, a combination of positive and negative social forces will exist simultaneously, which could cause confusion, especially without social-scientific scrutiny on a continuous basis. It is therefore crucial that the impact of these conflicting forces is identified and planned for long before settling on Mars. Today’s middle and high school students will be involved, and ARI’s mission involves a situation in which they will at least possess a basic astrosociology background to complement STEM. It should be kept in mind that the exercises that can be derived from these hypotheses are not trivial. In fact, for any given individual contemplating settling on Mars or anywhere else beyond Earth, each step from launch to hopefully old age is fraught with existential obstacles.

Several hypotheses are offered here that focus on the theme of sustainability in order to introduce interested parties, especially students, to concepts associated with astrosociological areas of study and research. Research hypotheses are extremely valuable because they provide a roadmap for future research and educational advancement. The ongoing goal is for students to become inspired to study astrosociological issues and educators will be incentivized to reveal the existence of

astrosociology and teach it in their classrooms although educators must also assist in the spread of this field on the astrosociological frontier.

Additionally, practitioners in STEM that include natural and physical scientists, technologists, engineers, and mathematicians can become enriched by being exposed to astrosociological issues, as this would expand a greater worldview for them. Understanding how the physical and social issues are actually interconnected will result in greater chances for settlements to be planned in all aspects related to social life beyond Earth. They can also contribute to teaching how the two branches of science should not exist in isolation but as totally integrated with one another in a complementary manner.

Diversity among students who study and perhaps someday practice applied astrosociology in a Martian settlement is extremely important. Studies have shown that heterogeneity among crew members and larger populations are more likely to experience lower levels of deviant behavior.^{xxvi} Input from students with varying backgrounds and cultures is a vital asset. Many factors will be important to understand because replicating a social system from scratch on a distant planet requires inquiries into a number of characteristics that involves both the settlers as well as the combined structures of their physical and social structures. Students with diverse skills and knowledge can combine their unique contributions to create a more holistic approach than would otherwise not be possible. The partnership between ARI and BSC strongly favors the implementation of diversity as indicated by the participating students shown in the figure above.



Without the social and behavioral sciences, human behavior would be much more of a mystery. Unfortunately, such a mystery will inevitably be the case in future space settlements without astrosociology and likely contribute to social problems that can be avoided. The human dimension of space exploration is vital yet absolutely under-emphasized. Students need to be made aware of the disparity between the physical and social aspects of social life in future human ecosystems beyond Earth. Instability can be caused by criminal activity, political strife, economic shortfalls, or discrimination, as examples, which are related to sociocultural and sociopolitical forces that exist within a given theorized space society.

Success in constructing physical elements such as spacecraft and habitat modules is a necessary condition, but it is not sufficient to address the human dimension that consists of behavioral acts and social systems with their interactive components. A future in which the social sciences and humanities can potentially provide insights not possible via STEM approaches alone. Without an organized population consisting of settlers who share the same or similar norms and supporting value, a sustainable settlement is impossible regardless of how well the habitat is constructed. A much more holistic body of knowledge that today remains underwhelmingly and frustratingly out

of reach. These research hypotheses must be considered in concert with physical and natural realities because they will add important complications affecting social-scientific analyses.

This essay provides students with areas to think about how contributions of the social sciences can affect long-term success and provides educators with areas to consider when creating research projects and assigning topics for term papers, theses, and dissertations. Without astrosociology in the classroom, a considerable lack of knowledge will exist when humans attempt to replicate a society in other space environments such as on Mars. Without such knowledge, the imbalance between the social and physical sciences will continue. A strong interaction between the social and physical branches of science within the space sector represents most likely the best approach given astrosociology's multidisciplinary structure along with the component that seeks to formalize the collaboration between astrosociology and the STEM disciplines.

The empty classrooms that characterize the astrosociological frontier represent the areas that serve to measure the progress of its settlement. With the assistance of organizations such as the Barboza Space Center, astrosociology will continue its development for the benefit of students, social groups, societies, and humankind in general. The frontier will increasingly become characterized with increasing numbers of classrooms that include astrosociology as part of teachers' lesson plans. At the moment, however, settling Mars is not practical because social scientists are not ready to participate in the numbers necessary for success in the long term. Astrosociological education and research must accelerate at this point in order to make this possible.

ABOUT THE AUTHOR

Dr. Pass founded astrosociology publicly in 2004 due to the lack of attention by social and behavioral scientists to astrosocial phenomena, or more commonly referred to the impact of space activities in space and on Earth. He also founded ARI in 2008 in order to formalize the development of astrosociology. Thus, the institute exists to develop astrosociology and further to grow the astrosociology community so as to create a better balance between the social sciences and physical sciences (and also the STEM fields and disciplines). While Dr. Pass is the first astrosociologist, the development of astrosociology requires that he is certainly not the last!



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