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Paper Session III-A - International High School Space Settlement Design Competition: How SECME is Preparing Me for a Space Age Education

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International High School Space Settlement Design Competition: A Model for Secondary School Education in Space Research

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Abstract

Co-founders Anita Gale, Dick Edwards, and Rob Kolstad originated the International Space Settlement Design Competition to provide high school students with the opportunity to present space-related design proposals in a professional setting. The competition uses the standard business RFP (request for proposal) format for competitors to present their designs for future human settlements in space. The competition draws on professional volunteers, from aerospace engineers to business executives, who mentor the student teams through the design proposal process. Using mentors from such diverse fields introduces topics to the students that they are often unfamiliar with, such as ergonomics and human factors, functionality during construction, and budgeting of resources. By using this format, the students not only gain experience in design and engineering for extraterrestrial environments, they also gain experience in real world business proposals, time management, team work, budgeting and cost benefit analysis. This paper reviews the procedures of this international competition and presents guidelines for fostering this same type of educational program at the local level.

International High School Space Settlement Design Competition: A Model for Secondary School Education in Space Research

The future of research and design in space-related disciplines rests in the hands of today's high school students. Encouraging bright students to develop an interest in the fields of study needed to conduct space research is an important goal. Many organizations, such as NASA, provide considerable support to this goal. One independent program which has been very successful in motivating students to delve deeply into space research is the International High School Space Settlement Design Competition.

The competition is an exercise of creativity, technical competence, management skills, environmental knowledge, teamwork, and presentation techniques. Each year the competition organizers develop a new design challenge, so that participating teams of students can experience working on an industry proposal team (Gale & Edwards, 2001).

In this paper, we discuss the advantages of this competition and suggest how it may be used as a model to encourage high school students to consider careers in aerospace-related fields. After providing some background about similar education support programs, we will describe how the competition works and discuss the advantages of this model for inspiring high school age students. Finally, we will provide suggestions for introducing similar models into local secondary school programs.

Background

There are a number of programs that encourage learning the disciplines surrounding space exploration. For example, NASA has invested considerable effort into supporting aeronautics and astronautics-related education. There are a wide range of programs for both teachers and students at the secondary school and college levels (NASA, 2002). At the secondary school level, programs range from educational seminars to apprenticeship and career-day programs. Other programs involve students more closely with space technology. For example, the Cooperative Satellite Learning Project at Goddard Space Flight Center involves high school students in the process of developing and operating the Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX) satellite. This program demonstrates how NASA implements a specific mission and introduces students to careers in space. Similarly, the Dryden Flight Research Center Robotics Education Project involves students in designing, manufacturing, and testing robots to perform different tasks. In all, NASA has nearly 150 education support programs aimed at secondary schools alone (NASA, 2002).

At the university level, several colleges have engineering competitions. Current programs such as the World Solar-Car Rallye, and the University of Vermont's in-school robot war competition, or the American Association for Artificial Intelligence (AAAI) Robotics Exhibition and Competition under Brown University, provide excellent engineering challenges for college-level students.

About the International High School Space Settlement Design Competition

This competition takes place in a simulated future: the year 2036. Technological advancements beyond the current state-of-the-art have accrued. An organization called the "Foundation Society" has issued a Request for Proposal (RFP) to build a cost-effective mining settlement on the moon. Several companies have decided to bid on the RFP, including "Dougeldyne AstroSystems," "Grumbo Aerospace," "Rockdonnell," and "Vulture Aviation." The design teams from these companies have less than two days to develop and present a design proposal for the lunar settlement which will win the contract. Each company has a similar organization with four main design departments; structural engineering, operations engineering, human engineering, and automation engineering.

The example companies are based on a composite of real corporations, projected into the future. Although a mythical organization, the described efforts by the Foundation Society to foster commercial space infrastructure development could, however, be accomplished by other existing organizations.

The basic products, vehicles, and structures described for this competition are technically possible within the timeframes indicated. They do, however, represent ambitious technical, economic, and political commitments, some of which design competition participants may work on during their careers. The proposals are judged by engineers with experience in the aerospace industry, so designs are based on reasonable interpretations of the level of existing technology defined here, the laws of Physics, and common sense.

This competition is noteworthy in that it combines the real world aspects of time-pressure and RFP's with interdisciplinary teamwork of real world organizations. As pressures and time constraints rise, the high school students begin to see how business aspects, cost, and politics effect the design process. Also, from the mix of disciplines, issues such as the benefits of facilities becoming operational during construction process versus the need for social and recreational facilities become topics in design that may have been overlooked from a single-discipline view.

Competition Details

The competition is conducted in two phases; the qualifying competition and the finalist competition. In the qualifying competition, teams from competing high schools create and submit designs for a space settlement based on a preliminary RFP which summarizes the requirements for the space settlement. When the teams register for the competition, they receive the final RFP, which describes requirements in detail. The teams use this final RFP to complete their design. From these final designs, the top eight teams are selected. These eight finalist teams are invited to the finalist design competition at the Kennedy Space Center.

The final competition starts with a general welcome meeting where the competition is explained in detail and the RFP for the competition is explained and handed-out. The eight Finalist teams are paired to form four competing companies. Next the teams divide their members into specialists: structural and automation engineering, human engineering, operations engineering, and management and marketing. Workshops for each specialty are taught by experts in the different fields, who volunteer their time. After the workshops, teammates rejoin to start the projects. The teams work in conditions that resemble those experienced by members of high-pressure proposal teams in industry, with assistance from real engineers and managers. Volunteer specialists are available to assist and act as "consultants" for the teams. Emphasis is placed on priorities that even university courses sometimes don't teach: consider your customers' needs and desires. The students are guided to appreciate that designs are driven by the customer's requirements. Materials are provided that help students get answers to any questions they have while they are in the process of developing designs. Background articles and a library of books that cover topics from space environments to agriculture, from radiation protection to housing design, and from robots to management practices, are available during the competition.

In the final day of the competition, the teams present their proposals before a panel of judges and their peers and presenters answer the judges' questions about their designs. The judges select a winning design, and provide a debriefing describing merits and weak points of the proposals (Gale & Edwards, 2001).

Qualifying competition teams may be of any size. The eight teams that qualify for the finalist competition are limited to 12 members, all of whom must be high school students, and two adult advisors. Teams are advised to select members with diverse experiences and/or interests, since successful designs balance structural integrity, operating efficiency, use of computers and robotics, and pleasant living conditions. Prior competitions have shown that it is also helpful to have at least one good artist and/or one good writer on your team.

Advantages of the Competition Model

Competition creates a situation in which the individuals are surrounded by others who "support (their) efforts, acclaim (their) successes, and console (their) failures" (Coleman, 1961). Also, Carron (1984) found that recognition is one of the top four motivators of students, along with affiliation (making

friends), skill development (excellence), and excitement. Recognition from peers and the community in general gives students an incentive to perform well. Coleman (1961) found that high status in the "adolescent society" was seldom based on success in academics. Instead, high status was given to those students who participated in athletics. One of the reasons that athletes were given high status positions, according to Coleman, was because these students brought "glory" to the school. Recognition from fellow peers and the community in general gave the athletes an incentive to perform well. If students were provided with opportunities for competition with their counterparts from other schools in various academic areas, such as aerospace, they could also bring "glory" to the school. This could increase their social status, which could provide motivation to learn (Brunsma, Khmelkov, & McConnell, 1996).

This model has a number of advantages which makes it an interesting and educational experience for high school students. The goal of each design team is to represent their "company" and develop a proposal for a space settlement which will be presented to the "contracting organization," who then selects the best design. Using a proposal format presents students with some of the realities of aerospace project development in industry. They are forced to work under time and budget constraints, as well as multiple design options and differences of opinion. Yet they must settle on a design strategy quickly so that detailed facility design, operations, and budgeting, often the bulk of the effort, can be completed in time to meet the deadline. As the work progresses, they must make compromises between design options, operations requirements, and cost.

Projecting the designs far in the future focuses students on the long-range view of traveling, living, and working in space. It also allows them to consider more advanced technology – technology that has not yet been developed. Since their projects take place in the future when technology that is currently only theoretical would be more fully developed, student designers can apply technology that is still in the conceptual stage. This allows them to work around certain limiting technologies and focus on what can be accomplished beyond these technological limits. This does not mean they can invent miracles. Any technology they utilize must be logical extrapolations of current technology – and they must explain how it would be developed.

From Space and Ground Support to Personnel and Family Issues

In general, engineering competitions focus on students interested in engineering. This program offers a means for students with interests outside of engineering to get a glimpse of many different career opportunities in the aerospace industry. The interdisciplinary approach includes students with diverse interests who would normally not participate in an engineering design competition. In keeping with the realistic character of the model, the teams require the members to work in a number of different areas, such as operations and infrastructure, human engineering, scheduling and costing, and services, as well as at the traditional structural design areas. Thus, students with interests in the social sciences, economics, and business have an opportunity to participate in a design competition.

Since different groups frequently pursue different lines of reasoning, they are able to explore many diverse problems of living and working in space and conceivably come up with innovative solutions. There is the potential that their brainstorming may be the impetus that sparks future solutions.

In addition, the diversity of the design teams forces students to consider a wide range of concerns about living and working in a hostile environment. They must consider how people will work, how they will socialize, and what they will do if they need medical attention, as well as a myriad of other considerations. This emphasizes to them the complexity and challenge of living and working in space.

Guidelines for Applying the Model

The International High School Space Settlement Design Competition is a highly successful program. Using it as a model, similar programs can be implemented at a local level for high school age students. The following suggests a number of guidelines for those who are considering starting such a program in their area.

Dedicated organizers

Having dedicated people to organize and facilitate is necessary for any program of this kind. As with any competition of this nature, considerable work must go on behind the scenes. A few dedicated organizers can energize others to volunteer their time and expertise. Much of the success of the International High School Space Settlement Design competition can be attributed to a few dedicated people enlisting a diverse group of volunteers who contribute to the competition.

Challenging and realistic scenario

A challenging and realistic scenario sparks the interest of the student competitors and encourages them to expand their intellectual horizons. It often is a challenge to develop a scenario which is inspiring, while at the same time realistic. Choosing an appropriate time period is important. The scenario must be far enough in the future to be challenging, yet not so far as to enter the realm of fantasy. Since the expected future technology must be extrapolated from current know-how, choosing a time frame at the edge of current scientific thought may be a good starting place.

Competition style

Having groups compete for best design adds both interest and satisfaction, plus a touch of reality, to the student's efforts. Competing with other team motivates them to excel and also gives the team members the satisfaction of knowing that they have produced their best, even for the teams who do not win. It also introduces students to some of the realities of corporate competition for contracts.

Guide participants to information sources

High school students may not have the expertise to define and bound the problem presented in the scenario. Including lists of references and sources helps guide the students to the information they need and also helps them get a better idea of the problem space.

Provide basic organizational structure

Establishing a basic organizational structure in the competition gives the participants a framework to build on. Providing the structure of the company with different departments establishes the various types of skills needed as well as implying who might be interested in being on the team.

However, as with any creative endeavor, it is important to take care with the balance between structure and creativity. Forcing too much structure onto the teams may rob them of some of their resourcefulness. They should be free to manage the departments as they see fit, within the general organizational framework. This not only encourages creativity, it also gives them a chance to experience the trials and joys of management.

Focus on outcome

The final guideline we suggest is to focus on outcome rather than process. The aim of the competition should be the judging of the designs. Emphasizing the objective allows participants to develop and mature their process on their own. This maturing process provides one of the best laboratories for learning leadership and management, as well as interpersonal and group process. The volunteer experts are available to keep the teams from diverging too far from track, but they should take care not to be too directive. In the International High School Space Settlement Design Competition, the volunteer experts are considered "consultants" who can answer questions and provide advice; an excellent metaphor for how the volunteers should interact with the teams.

Conclusion

The educational basis for constructing the competitions in this manner, is to provide high school students with an experience as close to real life as possible in a weekend . During the competition experience, they learn to use skills that are needed in industry teams, and most of them come to appreciate

the necessity of math and science courses. The goal is not to force them into a specific career path, but to help them understand how industry works, that different career opportunities exist, and how each individual contributes to accomplishing the organization's goals.

This is an excellent opportunity for the aerospace industry to reachout to the students who are interested in human resources, business and contracting, as well as engineering and technically-minded students. As the industry expands, the needs of the industry are broadening to include a wider-range of specialized employees. This competition is an example of the direction in which education for the aerospace industry could take. The introduction of teamwork and a broad range of real-world tasks helps students see what is involved in working in this industry. The interaction between the students and the professionals in the field is a major benefit of the competition. With educational programs like those described in this paper, the aerospace industry has the opportunity to guide the educational paths of students who are already interested in the industry, and also reachout to students who may not have realized they were interested in aerospace careers.

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