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APOGEE

PEAK OF FLIGHT

NEWSLETTER

Using Rocketry In Multiple High School Subjects.

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Rocketry Across The Curriculum in High School - Part 1

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Model rocketry is a topic that many teachers use to motivate students and excite them about science. The Team America Rocketry Challenge has motivated more teachers to introduce the topic to their students. However, one of the drawbacks of the Team Challenge is that in most schools only a few students are involved in the challenge and therefore receive the educational benefits that rocketry has to offer. Tim Van Milligan of Apogee Components and I have corresponded via email this past summer about a unit that we implemented at our school (independent of the Team Challenge) and how it may get more students involved in rocketry.

This project was instigated by many conversations amoungst my school's science teacher and myself about giving our students different educational experiences than were in our math and science curricula. What we found was just what Tim preaches - *rocketry grabs and interests students in ways even we didn't dream.* Often rocketry is seen as a junior high level project and we want you to see that rocketry can be challenging for high school (even advanced) students and across several curricular areas.

While Apogee Component's booklet *Projects with Model Rocketry* gives you some ideas for many curricular areas, this article will give you some specific places to focus on; and maybe spur some ideas of your own.

How Did This Get Started?

A few years ago a colleague and I were searching for a student project where we could team his science and my math students together and would teach many lessons beyond curricular math or science. We wanted to challenge our students and stretch them in ways that we had never done before. Colleges and work places require skills today that we did not face in our days as students and we were seeking ways to better prepare our students for these challenges. We knew that many of our graduates would be expected to work in teams on projects and may be required to make presentations, sometimes with other colleagues. We felt we could do a better job preparing our students for these new avenues of the work force. We also wanted our students to experience long term projects which would force them to persevere and persist, sometimes in the face of dead ends.

Rhonda Cox, Trigonometry teacher, gives students a look at mission patch history and symbolism.

The rocketry project described here covered five curricular areas, designed for our high school students. The real beauty of this project is that it went beyond traditional learning. We found that our students experienced not just curricular lessons but also emotions often removed from learning - especially in math and science — emotions of pride and even joy (yes, joy) in a difficult job well done. This project will challenge your students in many ways they have not been stretched before.

As we discussed teaming our students for a project we believed that our students would receive unparalleled benefits from such a unit, but we could not come up with a topic which we felt would be equally challenging to both his students and mine. That is, until I became a B.A.R. - a Born Again Rocketeer.

I built and launched model rockets as a little girl with my dad and again as a young adult, but a few years ago I got back into the hobby. Because of my mathematics background I be-

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came interested in more than just building and flying rockets and did some research on the topic. I soon found that rocketry could be a challenging project for high school students in several areas. And so a new discussion began about teaming our students to work on a project.

Curricular Components of the Unit

The five curricular components that we developed started with trigonometry and physics. As my science colleague and I started working on this project, we soon realized that there were other areas that could be a part of this unit. I had read the book *Rocket Boys* by Homer Hickam (also known as *October Sky*). We thought this would be a great book for our students to read, but instead of putting another thing in the math and physics components of this unit, we wondered if an English teacher would join us. Sure enough, one was brave enough to oblige. After getting an English teacher on board, we realized that U.S. History is a subject which could deal with rocketry. Our U.S. History teacher gladly joined in agreeing to take a special look at the Cold War and the Space Race and their impact on American math and science and society in general.

Lastly, as we started thinking about events, we realized that we would need launch pads and controllers for our launch, but this could be an industrial technology project to build these items. And so our fifth component was hatched.

Physics teams check in their rockets with the Rocket Inspection Officer (Ben Ahring).

We had three learning goals for our students while working on this project (which we wrote before we had expanded this idea past physics and trigonometry). These goals are not course specific but are general educational goals. The first goal was teamwork. We wanted our students to work in teams to accomplish a complex task and learn to effectively communicate within and among the teams. Many teachers use group projects, however, this project is different because the teams work for a long period of time (six months) on their task. This really gives the students a unique opportunity to learn about working with people and communicating rarely given to students in high school.

Our second goal was research. We wanted our students to get a deeper understanding of research and development of an idea. We saw a need for our students to research scientific, mathematical, and technical ideas. This kind of research forces students to read and understand technical information which may be extremely challenging to them. Again, this is something that most high school students rarely do.

Our last goal was presentation. We wanted to provide our students with an educational opportunity to develop their skills to present ideas in many formats, specifically written, oral, and visual forms. We wanted them to present technical material, again something that is a rare opportunity for students at the high school level.

Curricular Components and Events

From our goals we developed the curricular components and events. Each of these items is uniquely complex, so this will be an overview of those components and events. The first component in this unit was English. Our English faculty team member is our junior English teacher (we are a small school with only one teacher for most courses). This worked well for us since the trigonometry students are mostly juniors. This also tied in nicely with our U.S. History component since it is taught to juniors.

The English classes read Homer Hickam's *Rocket Boys* which is a memoir about five high school age boys in the late 1950's. Motivated by Sputnik, the boys decide to build their

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About this Newsletter

You can subscribe "FREE" to receive this e-zine at the Apogee Components web site (www.ApogeeRockets.com), or sending an email to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

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own rockets in a day when there were no such thing as model rockets. The book is more than a science and math book. It is truly an inspiring book about young people who make a dream happen despite tremendous setbacks. The book also shows students a life in a different time and place that is truly intriguing.

Our students studied five themes in this book which appeal to high school students: Search for Identity, Pursuit of a Dream, Alienation, Science and Technology, and Life Lessons. They also studied the memoir genre, team roles, and their importance to the success of the team. This naturally led into our technical components. The English component is the first English unit of the school year. We felt that it was an important introduction to the technical components of this project because of its study of team roles.

My students told me at the end of the project that they thought this book was a integral component to their full experience on this project. After reading the book, students viewed the movie *October Sky* to compare the book and the movie (there are many differences - see Homer Hickam's website). As a side note, if you use this wonderful book, beware of the fact that it talks about very dangerous "experiments" by the rocket boys. It is worthy of a discussion in class about not trying to duplicate what they did (never build your own rocket motors). We sent home a letter written by Quentin Wilson, one of the rocket boys, which warned about trying what they had done (found at www.homerhickam.com/safety.htm).

The second component was physics. The physics students worked in teams to come up with two designs, one for each of two contests. The first contest was an altitude contest, the second was a spot landing contest. Of course, there are many others that could be used. The teams were only allowed to use certain materials provided for them and could only use certain motors, also provided for them. They actually constructed two rockets for each design so they would have a back-up.

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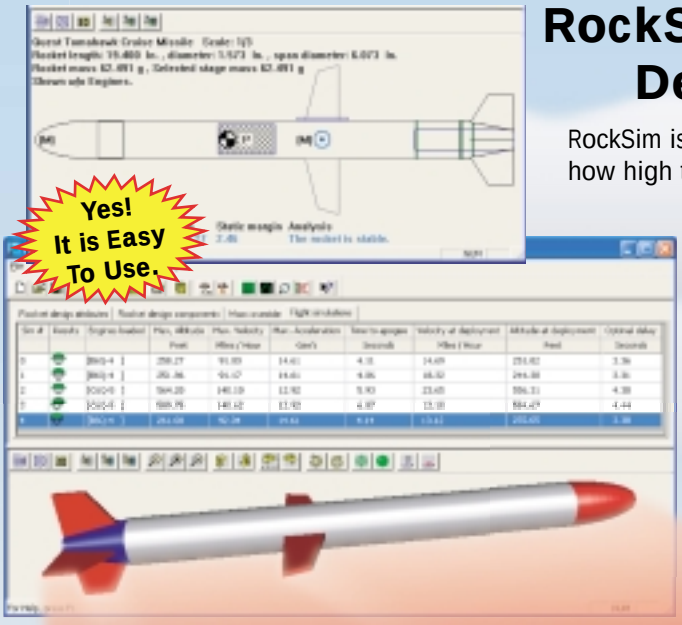

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To us one of the keys to the success of this component was the use of Apogee Components' RockSim computer software (www.ApogeeRockets.com/rocksim.asp). We wanted our students to work as an engineer. We found RockSim to be incredibly powerful, fairly user-friendly, and reasonably priced for school lab licenses. For more information about the benefits of using RockSim in your school see *Why Should You Use RockSim in Your Classroom?*

One of the things we decided to add to our physics component this year is to have the students build a kit before using RockSim. Many students have not had the experience of building a rocket and building a kit will give them constructions skills and ideas that will help them as they use RockSim. Before using RockSim you may have students design rockets with paper and pencil and even calculate center of gravity and center of pressure by hand (see *Calculating the Center of Pressure of a Model Rocket* or *The Handbook of Model Rocketry*).

Obviously, you can use the rocketry unit to discuss Newton's Laws of Motion and use rocketry as great examples of all three (see *Model Rocket Propulsion*).

The third component was trigonometry. The trigonometry students worked in teams to solve several problems related to the rockets and their launch. Some of the problems our teams worked on were altitude determination (beyond a simple altimeter and trig table), velocity and acceleration determination, parachute efficiency, design efficiency, and efficient tracking (ground) and recovery. There are other problems teams can work on. Teams that had to make calculations in the field had to write a program for their graphing calculator to use on launch day.

Trigonometry students use their theodolites to determine the rocket's altitude. [See related article in Apogee e-zine Newsletter #93]

Teams also had to develop a budget and build any tools they would need to solve their problems on their own. The altitude teams built their own theodolites (to measure angles of elevation and azimuth). Velocity and acceleration teams built their own apparatus to help them determine the values they needed. Parachute efficiency teams designed their own experiment variables, constants, and methods. In each case, the team had to perform a great deal of research to help them solve their problem.

The fourth component was industrial technology. These students designed and built our launch facility which consisted of the launch pads and launch controller. The instructor used *Electronic Model Rocket Launcher and Construction Plans a*nd Tips to aid in the decisions about what type of controller to build. Students can discuss pros and cons of different systems and decide how to proceed. They should also develop troubleshooting methods and can practice working with the equipment to solve problems that occur in trial launches before actual launch day (very much like NASA personnel practice for different missions and possible problems).

Industrial Technology students troubleshoot one stubborn launch pad that they built themselves.

The fifth component of this unit was U.S. History. This component coordinates with the English component since *Rocket Boys* takes place in the late 1950's during the Cold War and the beginning of the Space Race. If U.S. History is taught using a thematic approach, this can be taught concurrent with the English component. If U.S. History is taught using a sequential approach it would be the last component of the unit probably occurring sometime in the spring. Either ap-

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proach will work well with the other components.

Students worked in pairs or groups of three to research a space history event and make a space event poster of that event in space history.

Our unit had three major events. The first event was a Kick Off Field Trip for the technical components of the unit (industrial technology, physics, and trigonometry). We scheduled this so that we went shortly after the students had finished reading *Rocket Boys* (mid-October). The field trip took the students away from school to introduce them to rocketry and this unit (our math and science classes rarely take field trips so our students really enjoyed this). Our field trip the first year took us to a local museum which had a large enough room for our 100 students and was showing the IMAX film *Space Station 3D* which naturally enriched this event.

Since this IMAX film is no longer showing we are going to use *"Spider"* from the series *From the Earth to the Moon* by Tom Hanks and HBO - it is an excellent look at engineering and long term projects.

We gave the students a brief introduction to the whole unit, detailed information about their own course's component, and an introduction to basic rocketry. In the future we plan on giving the students a demonstration model rocket launch (live or on video) so they can fully understand the speed at which they lift off the pad (this really surprised our students on launch day).

We also gave the students a "lecture" on mission patches. We talked about their history and design. We used an LCD projector and Power Point to show them examples of different NASA patches and show them the symbolism used. The purpose of this activity was to introduce each team's first assignment: to design a team mission patch. We also scheduled team time for the teams to meet and discuss roles, problems, schedules, and their patch.

The second event didn't occur until April. This was our evaluative launch which took place on our athletic field. One goal of our launch experience was to give our students a feel for an actual NASA launch. Each of our 96 students (industrial technology, physics, and trigonometry) were assigned roles in the launch effort. We used Apogee Components' booklet *Conducting a Safe and Scientific Launch in Large Group Settings* as a guide in organizing this event. We put together a launch handbook for the students which we handed out about a week before launch. It had information about each launch role such as GO/NO GO indicators, who they report to, and when they must give a NO GO. It also gave them general information about proper communication procedures (we used 14 channel FRS radios), launch sequence, a launch range map, and general helpful hints about the day (like bringing sun screen). The students brought the handbook to the launch range and used it as a resource throughout the day.

Launch day started with setting up the launch facility. We then went to our gym and trained the students about communication on the range, the launch sequence, and everyone's role before, during, and after each launch. We had launch pad teams, launch controllers, security, public affairs officers, countdown announcers, rocket scientists, weather officers, inspection officers, etc. After training inside we went to the field and held a practice set of launches. Finally, we did our 30 evaluative launches. Each physics team launched their altitude rockets three times and their spot landing rocket three times. Careful planning is crucial to this event and safety must be your priority.

Our last event was held about a month after the launch. This event was called our Mission Expo and we held it in our school gym. Each curricular component was involved. The English classes had a display of their work from the *Rocket Boys* unit. The U.S. History classes organized their space event posters in a timeline around the walls of our gym. The center of the gym was filled with displays by the trigonometry and physics students. These teams also gave oral presentations of their work during the Expo. The industrial technology students set up a launch facility display. We had other displays of the weather equipment used on launch day, rocket materials provided to the students, inspection tools, and communication equipment. We had a Power Point slide show of photos of the field trip and the launch event set to music. The public was invited to this event and we had a great turnout.

Cornerstones of this Unit

The great thing about this unit is that it is extremely flexible and can be developed to fit any school situation. There are, however, cornerstones to this unit which make it a unique and unparalleled project for our students.

First, in the technological areas of this project (e.g., industrial technology, physics, and trigonometry) the students must work in teams. One of the unique aspects of this project is the opportunity for students to work on a long term project with a group of people. It is a unique lesson in interpersonal skills. We used teams of four or five members.

One other important part of this cornerstone is that each member of the team has a specific role on that team such as leader (which we called the CEO), team scientist, communication specialist, project manager, and financial officer. These

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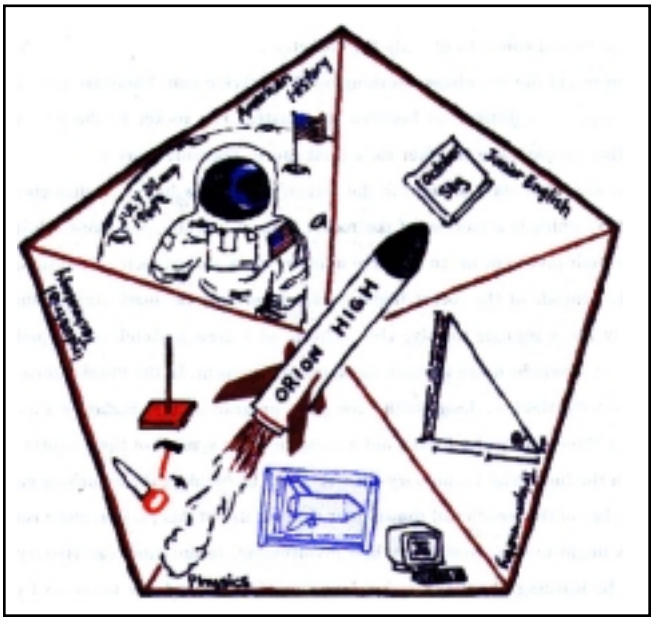
roles, of course, can be altered to fit the particular goals of your project. One complaint of most students when working on team or group projects is that one or two persons do all the work. We found giving students specific roles this problem was rare. One of our students commented, "I used to not like working as a team because someone always did not do their fair share. This project was different, everyone had to do their fair share or else we wouldn't have gone as far as we did." Each role should have specific responsibilities and accountabilities to the team. They were evaluated by their team members according to their contribution. Without specific roles the team will not be able to function toward a common goal.

Second, much to the students' disdain, the teams should work on this project primarily outside of class (at least in physics and trigonometry). They should be in charge of setting up their own team meetings which teaches them how to compromise, communicate, and work around each other's schedules. It also teaches them about prioritizing. Also, from a teacher's point of view, if they did not work on this mostly outside of class you would have to give up too much curriculum to make this project practical for almost any upper level course.

Third, you must help the students keep themselves organized and on task. In order to do this you must provide them with regular due dates throughout the unit, each with progressive goals toward the final product. In trigonometry I had the teams prepare five reports that were due over the course of about four months. Each report required different information from the students.

The first report was a planning report where they laid out their team plan to solve the problem they were working on. This is important because it teaches the students that the team must plan before they start working, it gives the team a focus, and each member's part toward that plan. The second report was to brief the teacher on the team's progress on their plan. The third report was the solution report where they detailed their solution to their problem. In this report they also evaluated their budget, how they worked as a team on the problem, their plan, how well they worked their plan, etc. The fourth report was an event planning report for the students to give their plan for the display and oral presentation at the Mission Expo (due before Launch Day). The fifth report gave the final outlines and display plan. This was due about a week before the Mission Expo. Students felt that these regular reports were a key for them keeping on task for the long period of time that they worked on this project.



Our project patch was designed by one of our Trigonometry students. The front cover was drawn by Lisa Cush based on this design.

As a fourth cornerstone, for this project to be a learning experience in team dynamics, teams need to evaluate their work with their teammates. As mentioned above, one of the trigonometry reports required the team to evaluate how they planned, worked, their budget, method of researching, team communication, etc.

Fifth, each team (trigonometry, physics, and industrial tech) was required to design a "mission patch" similar to those that astronauts and scientists design for their NASA missions. This may not seem like it would be that important, however, it was a fantastic team-building exercise at the beginning of the project.

The mission patch was the first assignment that each team had and it forced the teams to discuss and make decisions early in the project. With the drawing of their patch they had to submit a written description of their patch and explanation of the symbolism used. Each team was very proud of their mission patch.

We also had a contest to design a mission patch to represent the entire project. The winning patch represented each of the five areas very well. In the future we plan to have students design a patch for each component of the project (trigonometry, physics, and industrial technology). We affixed the project patch to just about everything we produced for the project. The students were especially proud of their patch on launch

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day when they picked up their launch range badges and saw the project patch and their team patch on their badge.

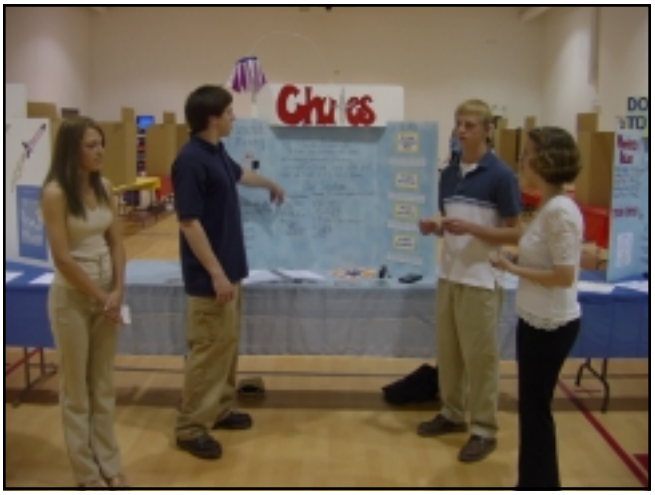
Lastly, you must have a culminating event for the students to present what they did and learned. I don't believe this project would have had the effect on our students that it did if we had not had our Mission Expo. Besides fulfilling many of our presentation goals, the Mission Expo allowed our students to "show off" the great things they learned and did in this project. Our students really looked at it that way, that it was an opportunity to share with each other and the community what they had done and how much they had accomplished. Remember, they worked for six months on this project.

Many of them truly relished the opportunity to share with others what they had learned and I believe that giving the students the opportunity to share with others is priceless - and too rare.

How to Get Started

The first and most important step of planning a cross curricular unit is to choose the faculty team. You need to find people who can work well together and who have the interest of their students at heart. You must also look for other faculty members who are willing to work hard in planning and implementing this unit. The first year you do a project of this magnitude will involve a lot of time in planning. But, I will tell you from a teacher's point of view, it was worth every minute we spent on it to see the excitement on Launch Day and the pride at the Mission Expo (the gym had a energy that to this day I can't explain, but warms my heart). We started working on this unit about six months before we implemented it and met about 20 times. If you have already started the school year and would like to do something this year, start small with maybe just trigonometry and physics. If you teach in a larger school, you may want to start small the first year and only involve one teacher from each curricular component. You can always build from there.

The second thing that should be done is setting goals for the unit. As we started discussing the rocketry unit, we realized we were putting the proverbial cart before the horse; we should first decide what it is that we wanted our students to get out of this project. We needed to answer questions like: Why should we do this type of project with our students and what do we expect our students to experience in this project? Before we discussed more than just the very basics, we wrote down our goals for the unit. This helped us frame the curricular components and also choose and plan our events. The way



Trigonometry team presenting results from their parachute efficiency study during the Mission Expo at the end of the unit.

we evaluated our students and how they were asked to evaluate each other was also based on our goals.

The third step is actually a warning. Keep it "small" the first year. Our first year we had five curricular components. In our early meetings we brainstormed many extensions beyond those five components such as art, journalism, and computer multimedia. They were great ideas, but we realized quickly that we could really go wild. For our first year we believed it would be in our best interest if we just focused on doing a great job in the five areas we were already developing.

Conclusion

I firmly believe that one of the strenghts of this unit is its flexibility. It is a project that can be adapted to any school situation and for any combination of courses. We used five curricular components. You may only focus on two or maybe three. I do believe that the central components are science and math. The other components enrich the experience for the students. Maybe you will be able to incorporate more than five components. The only thing that limits you is your imagination. This article is intended to give you some practical ideas of how you can use rocketry as a challenging project in the high school curriculum, but you can mold it your needs and school environment. You will face some challenges that you must be willing to deal with and overcome. But again, the experience your students will have is worth the effort. One of the challenges that many schools may face is a major concern: where do we hold the launch? We are fortunate to be a school in a small, country town, with a large property. Even though we are about 10 miles from an international airport we

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were able to make this work. You may have to go off your school property to hold your launch. For help with this problem you may want to turn to your local NAR section or Civil Air Patrol Squadron (CAP units often have model rocket launches for their cadets, so they may be able to provide you with some ideas).

Our students reflected after the unit that this project taught them more about working on a team than anything they had experienced in the classroom. Students reflected that they experienced pride and great satisfaction in what they as a group had accomplished. They commented that in some ways they felt like the rocket boys of Homer Hickam's book - succeeding despite set backs. I can tell you that we, the teachers, were truly blown away at the Mission Expo. The students were a testament to my teaching philosophy - if you challenge students and believe in them they will exceed your expectations. We were so impressed with the displays and the quality of their presentations. Several students actually commented they never knew a school project could be so much fun! Many students reported that they would always remember their feeling of accomplishment following this unit. One student stated, "I will take with me knowledge to know I can overcome anything (possibly with help). Honestly, at the beginning of the project, I thought it would be too hard to determine the altitude." What wonderful gifts to give young people.

Acknowledgements

Any project of this magnitude involves the dedication of many people. Special thanks go to the faculty team from Orion High School: Ben J. Ahring, Jr., physics; Scott Briney, U.S. History; Becky Light, English; and Gary Pinger, Industrial Technology. Thanks also goes to all the faculty and staff, without their patience and support this would not have been the positive experience for our students that it was.

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