INNOVATION APPROACH TO STEM

EDUCATION WITH A COMPUTER GAME, SANDBOX AND ROBOTS

By: William Lovell, CEO, c-Link Systems, Inc.

OVERVIEW

Times have changed since I was in Junior High School or Middle School. Prior to that during the summer I spent hours in the woods or sand pile when not helping on the farm or around the home. It was during this time I realized that being an engineer was everything. Fast forward to today and the after school club I work with has never played in a sand pile with trucks, cars or hundreds of little green army men. But they have played for hours on a computer of one form or another. Students that I have conversed with over the years do not have an idea what they want to do in life. It seems my generation was “odd” we all had some idea of what we wanted to do.

OUR FUTURE

The young people that do have some direction only have dollar signs for the most part as a driving force. Not the best idea for the future. As a business owner I watch the market and labor pools and check the statistics on manufacturing, which over the last few years has been pretty dismal.

According to the latest reports from the Department of Labor, Bureau of Labor Statistics with projection:

Industrial Employment	Year	In thousands of jobs
	2000	146,236.30
	2010	143,068.10
	2020	163,536.10
Occupational Employment		
	2006	150,620.00
	2010	143,068.20
	2020	163,537.10

Table 1 U.S. Job Numbers

The STEM process in schools is necessary for the future of our existence. With this in mind we decided to push the envelope to show the middle school kids what is "out there" for them in the future and hopefully more than a paycheck.

RADICAL METHOD

THE PROGRAM IS AN ATTEMPT TO TEACH MATH, BASIC MATERIALS SCIENCE, ROBOTIC MOTION, CREATIVITY, TEAM WORK AND SAFETY IN THE WORK PLACE.

The conventional approach to teaching some subjects is not as effective as other methods. Having spent time utilizing the "old school" approach with high school students I reverted to a military approach. We went to total hands on with a minimum of "chalk board" time, the only white board time was for explaining an asked question or process/procedure review.

After-school programs for middle school students become an even greater challenge with time constrains in hours per week, budgets and the hyper drive with short attention span young students have. After scrutinizing the conundrum for the last 8 months an elegant solution was hit upon that could in old school parlance "rock the house". We will use; a computer game that all of the middle school students would show me their progress in, robotic vehicles made for outdoors and a big sand box.

We start with a computer game called Minecraft®[1] a sandbox indie game with a Lego® look about it. This whole scenario takes place on a world where you can construct whole towns, gather/grow resources or do as all Middle Earth Dwarfs do and delve deep into the mountains. I am partial to the Dwarven theme. The version is actually MinecraftEDU; this package has a large educator backing and utilization. It is low cost in comparison to other STEM or robotic packages. Because this is a pilot program and a work in progress it will be limited in size and scope.

HOW IT ALL FUNCTIONS

As stated above we are going to show, explain and hopefully they comprehend different real world applications utilizing the game and miniature robotic vehicles. Take away concepts form the game will be the overall design of the world, volume of material, construction practices. In the game very few tunnels collapse after they are created, demolition does not leave large scale debris, and your character can fly (makes building tall walls easy). With the EDU version we can limit functions and tools. Students are given a preconfigured world, which matches the sandbox they will work with later; scale 1/125. They are required to, as a team, create a main building with 4 lesser buildings (castle with 4 huts), a bridge over a ravine and it must hold the weight of at least one robot and a tunnel. The sandbox with its scale represents a ground area of 381km x 608km (238mi x 380mi) I would not want to have to walk it.

The group will have to calculate how much sand to remove/add to build the town, number of blocks per building (they will be using actual Legos). The bridge has a similar arrangement for moving of sand and number of blocks plus an open review of the bridge prior to putting it into the sandbox. The tunnel is one they are already thinking on; sand is not a good tunnel medium, as anyone with green army men can attest too. Not only are they going to have to figure the volume of sand to remove but how many trips the robot hauler will make but how to shore the tunnel up so as not to have it collapse on the robot. Having to notify MSHA of a tunnel collapse on a robot could be an interesting exercise for them. Figure 1 depicts the basic sandbox with a realm configured for the students to work with. The sandbox was designed to a scale to approximate the MinecraftEDU realm; scale is 1/125. This generates teeny tiny robots and building blocks; the blocks actually a footprint correlation of a single Lego block to a Minecraft block, height being the only non-considered variable. A drawing package for the construction of the sandbox will be made available to anyone requesting it.

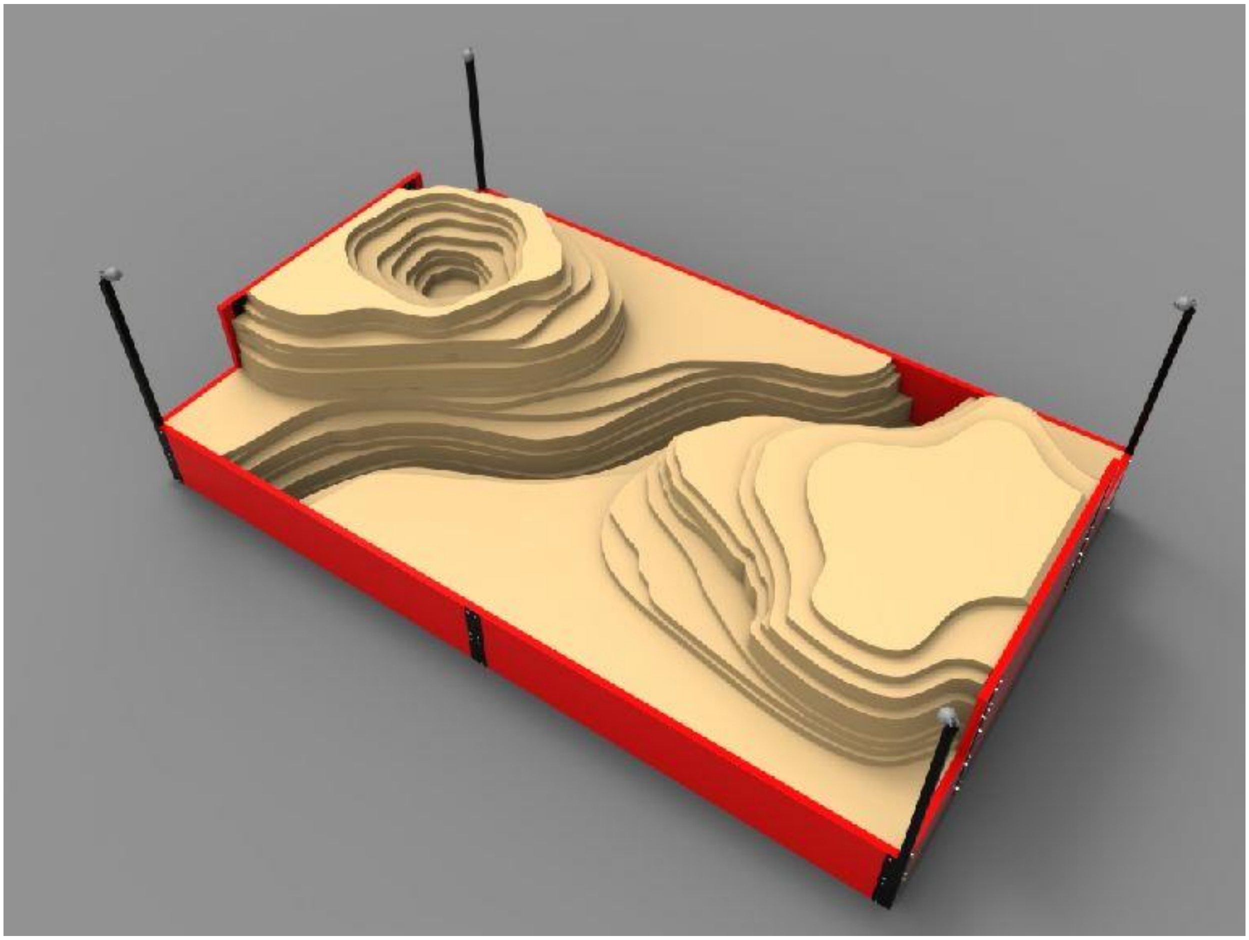

Figure 1 Example of Test Sandbox

As the whole package is slowly brought together and things become physically visible students start to get excited. Of course there is a catch, the robots will be tele-operated, another words remotely run via a camera and console. We have seen two reactions those that start begging to be the first to try and the others that tell you they can't do it. The first robot group will be a bulldozer (Trak-Bot[3]-BD), a tunnel hauler (Trak-Bot-TH) and a dump body (Trak-Bot-DB). This will be followed by a unit with a 6-axis arm for doing assembly (Trak-Bot-6DoF) and the final unit will have a 3D printer system for sand (Trak-Bot-3DP). These units are tracked and scaled to fit the scenario sandbox which makes them very small, chassis is approximately 4 inches long. Each unit will have a camera mounted on the top for vision control utilizing a wireless connection; these are routed to an operator console. There is a console per robot with the current configuration being 5 robots. Figure 2 contains an approximation of the total system configuration as currently being deployed for 3 students or teams. The console will have a 17-inch monitor that displays what the camera is looking at with vehicle data in a status band across the bottom. Status information will be pitch and tilt of the unit, battery level, speed and payload condition i.e. blade up or down.

The final Trak-Bot the -3DP will be late in the school year. This system is a scale down of a full robotic system that is currently in development. In most cases things are scaled up, made larger, this is slightly easier though the scaling can still bring its share of issues. The opposite will be done in that the 3D printer will be a down scale by an approximate factor of 18. This action will require the design and development of a new pump system and nozzle for the sand. All those issues aside the Trak-Bot-3DP will allow greater creativity with the students. With this unit the students could do other design projects in a smaller sandbox or even table top.

The classroom wireless is configured to handle both the custom operator stations and the MACbook Air the students use to run Minecraft.

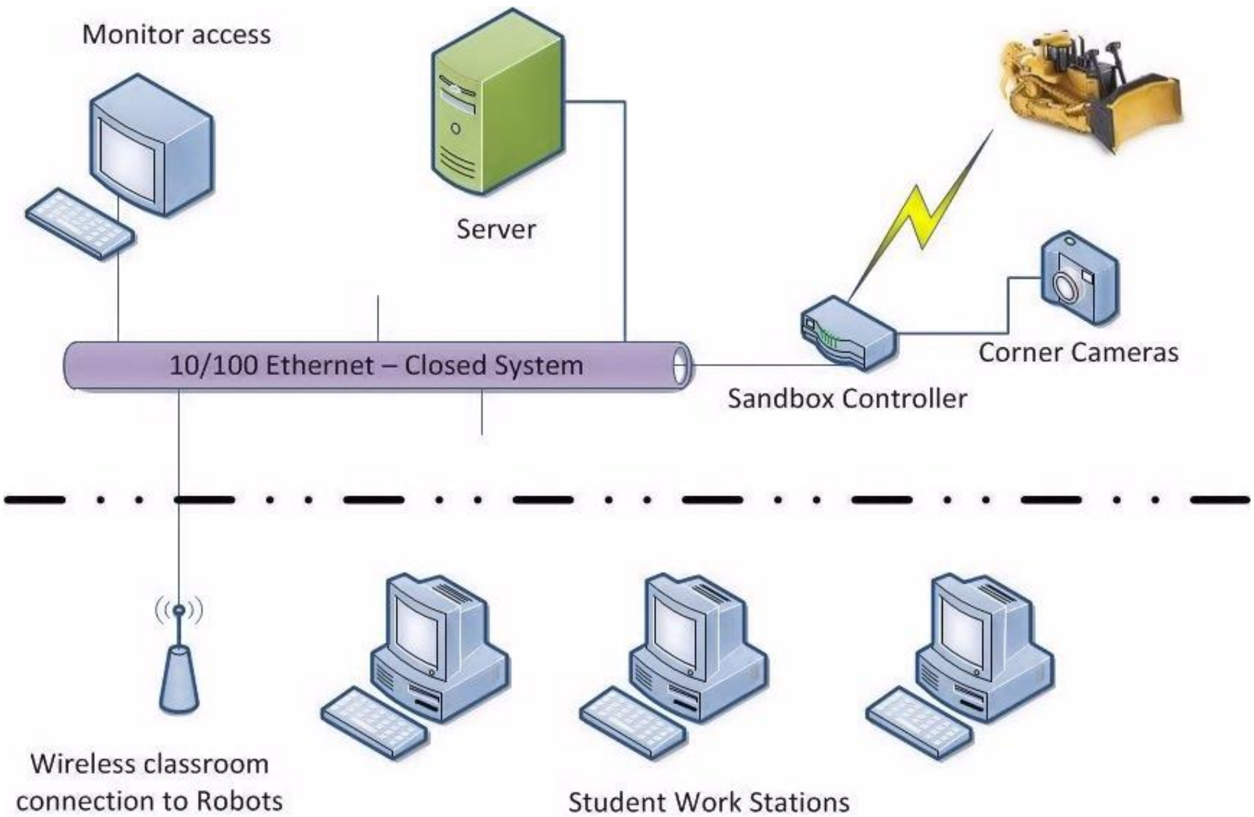

Figure 2 Current System Configurations

The education community needs to understand that this is a teaching/real life experience project for the students. The use of MinecraftEDU, a game, is for the design base of the creating world platform. Any 3D modeling software could be used but would require a larger learning curve with a larger chance for boredom or drop out. The use of tele-operated equipment is real life, the only difference being size. Caterpillar Corp. has remote controlled systems for their mining equipment such as the D11T bulldozer, see Figure 3, with Cat® MineStar™ System[2], this unit weighs in at 115.3 tons, not to your fathers lawn tractor. They also learn about basic guidance systems and stabilization, traction (yes you can bog a tracked vehicle) and how to understand what the proximity sensors are doing. The tele-operated and autonomous capability is not just for the D11T. There are numerous mining operations,

Figure 3 Caterpillar D11T

open pit style, where a Cat 797F dump truck drive themselves to and from pickup and drop points, see Figure 4. From the above ground to the underground there is equipment that will require all the gain able knowledge of the next generation as with the unit in Figure 5.

Figure 4 Cat 797F

Finally these young people are building something they designed based on a few minimum requirements.

Figure 5 Sanvik DS421

SANDBOX ROBOTS

THE REAL PLAYERS

In an attempt to keep the scale as real as possible new Trak-Bots were designed. The new units are still larger than the scaling calls for but miniaturization can only go so far.

Figure 6 has the initial family as they have been modeled; the basic chassis 3.75inches edge-to-edge on the tracks and a total of 5.5inches in length, the height will vary depending on camera and configuration.

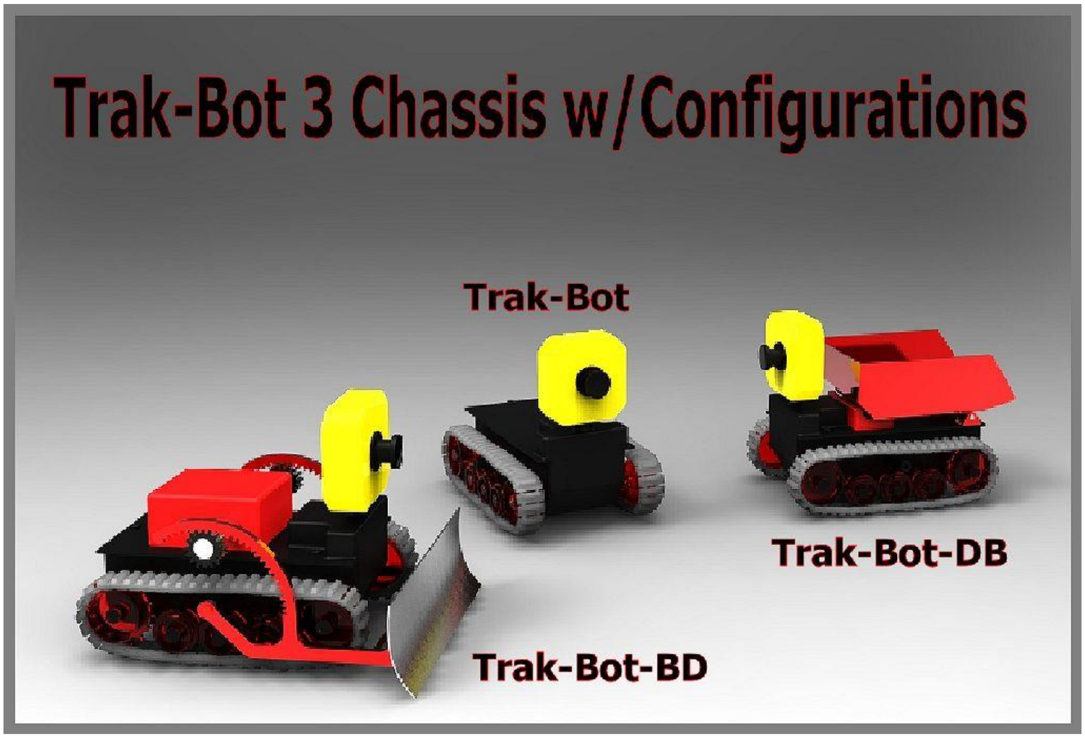

Figure 6 Trak-Bot 3 Family

FUTURE

Because this is an on-going evolving project, portions will come and go as it is smoothed out expanded or contracted. MinecraftEDU already has a large following with lessons and worlds created by other teachers for specific functions. I am currently looking into adding the tracked vehicles into Minecraft through a Mod and running on “redstone”.

So as not to create the notion that the whole project is game based only, here are some other project ideas. Remember it is a sandbox so it can be shaped prior to starting a project :

1. Remote creation of a lunar base. Units can be used as tele-operated or autonomous. A response time lag can be built into the control console. The autonomous scenario teaches the student how to program.
2. Robotic construction of a building by using a 3D printer.
3. Practice mine tunneling.

The user can determine what is possible.

The robots can be used for just robotics, the special functions can be removed and now you have a mini-camera on tracks running around. The ability to program the robot to run autonomous is available which now brings a class into “C” programming and autonomous control with guidance systems. Usage of all or part is virtually limitless.

There will be a second section to the paper as the sandbox begins actually running.

REFERENCES

1. Minecraft: ***Minecraft*** is a sandbox indie game originally created by Swedish programmer Markus "Notch" Persson and later developed and published by Mojang. As per Wikipedia article.
2. Cat® MineStar™ System is a registered trademark of Caterpillar Corp., A remote control package for large scale Caterpillar equipment.
3. Trak-Bot is a product family developed by c-Link Systems, Inc. for educational purposes.
4. Equipment images from respective equipment OEM websites.