Techfacturing: A Summer Day Camp Designed to Promote STEM Interest in Middle School Students through Exposure to Local Manufacturing Facilities

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Abstract - "Techfacturing" is the name given to a three day summer day-camp for middle school students that was implemented in summer 2009. The goal of Techfacturing is to encourage local students to pursue Science, Technology, Engineering, and Math (STEM) based careers in order to support the talent pool for local industry. Techfacturing participants are introduced to local electronics, medical supply, and snack manufacturing facilities as well as college campuses. The day-camp is aimed at middle school students with the intent of influencing their academic decisions as they enter high school.

Camp activities include small-group projects for the participants as well as exposure to local manufacturing plants through tours. College students participate extensively as mentors, minders, and small-group facilitators. This paper describes the camp activities and organization in enough detail to facilitate transfer to other outreach attempts. Our inaugural event was effective in providing middle school students with a quality experience as well as generating ideas for improvement. We measured our effectiveness in three ways: response of participating students to a survey, response of parents to a survey, and observations made by camp staff. The results of these measurements are shared and discussed along with significant lessons learned and our planned next steps.

Keywords: STEM, day camp, middle school

INTRODUCTION

Techfacturing is the name given to a day camp designed to interest middle school students in STEM education and to expose students to career opportunities available in the Shenandoah Valley. The camp was developed by a team of administrators and faculty members at Blue Ridge Community College (BRCC) and James Madison University (JMU). Participation in the camp was limited to fifty students. Funding for Techfacturing camp came from a Community Based Job Training Grant (CBJTG) that was awarded to BRCC. The units involved from BRCC include Blue Ridge Tech Prep and Manufacturing Engineering Technology (MET); the units involved from JMU include Outreach & Engagement, Integrated Science and Technology (ISAT), and the School of Engineering (SOE).

The intent of this paper is to provide practical information to those that currently provide similar opportunities, or are considering doing so. To this end we provide an overview of Techfacturing organization and funding, information on comparable events developed elsewhere, and a description of Techfacturing activities and tours. This is followed by an evaluation of Techfacturing based on the results of surveys of camp participants and their parents as well as observations by the camp developers. Finally, our "lessons learned" are included as recommendations for future iterations of Techfacturing.

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TECHFACTURING ORGANIZATION AND FUNDING

Perhaps the greatest hurdle to overcome during camp development was to determine how the camp would be organized, how long it should last, and how to fund it. We chose to keep the camp days and the entire camp relatively short in order to keep the campers engaged as well as to keep the number of activities to develop and tours to schedule at a manageable level.

Camp Organization

Techfacturing camp lasted for three days, the first two days had similar schedules; day three had more significant variation. The camp schedule is shown in table 1, below.

Table 1: Camp Schedule

Day One	Day Two	Day Three
8:00 - 8:15 Arrive at JMU	8:00 - 8:15 Arrive at JMU	8:00 - 8:30 Arrive at JMU
8:15 - 11:00 Group activities at JMU and BRCC	8:15 - 11:00 Group activities at JMU and BRCC	8:30 - 9:30 Complete activity
11:15 - 11:45 Lunch	11:15 - 11:45 Lunch	9:30 - 9:45 Break
12:00 - 1:00 Travel time	12:00 - 1:00 Travel time	9:45 - 11:15 Prepare for presentations
1:00 - 2:00 Tours in groups	1:00 - 2:00 Tours in groups	11:15 - 11:45 Lunch
2:00 - 3:00 Travel back to JMU	2:00 - 3:00 Travel back to JMU	11:45 - 1:45 Presentations
		1:45 - 2:15 Discussion with parents

All of the participating campers arrived at JMU on the first day and were split into four groups of about 12 campers each. Two groups stayed at JMU, and two groups traveled to BRCC for activities and lunch. After lunch, teams traveled by bus to a tour destination. After the tour, all students were returned to JMU to meet their parents. The second day was similar, but with groups trading tour destinations. Day three also began at 8:00 AM and included an activity, however all of the day three activities were completed at JMU. After the activity students prepared for their presentations, had lunch with their parents, and made their presentations. An additional presentation regarding opportunities at JMU was made to students and parents followed by a brief discussion with parents. Techfacturing camp was concluded by 2:00 PM.

Each of the four groups of campers was hosted by a faculty member and between two and four college students. The campers stayed in the same groups throughout the camp to develop trust between the campers, college students, and faculty. The college students had two distinct backgrounds: technical and education. The students with technical backgrounds came from the MET program at BRCC or either the ISAT or SOE programs at JMU. The education students came from the Masters in Education program at JMU.

Description of Funding Source

Funding for Techfacturing Camp came from a Community Based Job Training Grant (CBJTG) that was awarded to Blue Ridge Community College by the U.S. Department of Labor/Employment and Training Administration (CB15244-06-60). This grant includes a youth outreach initiative with the following objective:

> Introduce youth to manufacturing and distribution career options. Involve and educate students, parents, teachers, and guidance counselors within [the] region.

Intended outcomes of the grant include educating parents and students about industry career pathways, education options, and workforce opportunities. This outcome supports meeting the challenge to boost resident education levels, skill sets, technology skills, and workforce capacity.

The total budget for Techfacturing was approximately $10,000. This included: $4000 for faculty stipends, $1500 for student assistant stipends, $2000 for lunches, $600 for t-shirts, $600 for travel expenses, $350 for educational materials, and $400 for advertising.

Comparable Successful Events

A variety of agencies have developed activities and curricula designed to interest middle-school students in STEM education and careers. These efforts range from independent attempts to large scale franchises such as Project Lead the Way or First Lego League. Developing a partnership with one of the large scale entities has its advantages, but not all pre-determined approaches can be readily tailored to fit within the specific time, space, and theme parameters of an individual outreach attempt. It is of interest to note what sorts of activities are promoted by a range of STEM outreach efforts before developing one's own.

Large Scale Efforts

The following events are sponsored by national organizations. This provides the advantage of a proven curriculum as well as opportunities for support.

- Destination Imagination is an after school activity and tournament program that reaches over 100,000 students across the U.S. as well as in more than 30 countries. It allows students to test their ingenuity in a variety of skill sets, which include technical, mechanical, and architectural design [Destination Imagination, 3].
- FIRST Lego League is a partnership between FIRST, (For Inspiration and Recognition of Science and Technology) and LEGO Group. The League creates a competition between younger students to design, build and program robots made out of LEGO kits. FLL hosts tournaments worldwide. 45% of kids who participate in FIRST LEGO League expect to have a Science & Technology related career, as opposed to 20% in the control group[USFIRST, 10].
- The society of Manufacturing Engineers, in partnership with Project Lead the Way (PLTW), offered three distinct programs across 36 states in 2009, all intended to get elementary, middle and high school students involved in STEM disciplines. Gateway Camp is designed to introduce elementary school students to STEM concepts, and foster an interest for future PLTW activities. Gateway Academy is the for Middle School students, it gives them opportunities to get hands on experience with technologies such as robotics and aeronautics. They also do STEM related activities such as building bridges or race cars. Finally, the sMe Institute program allows upper level high school students to get involved in a specific industry or career path, so that they may consider STEM disciplines when looking at post-secondary education options [SME Education Foundation, 8].

Independent Efforts

In many cases, the objectives of a large scale effort may not mesh well with local objectives. Although significant time and energy is required to develop an independent event, the rewards can also be high since the event can be tailored to mesh with local economic and educational needs as well as local resources. Furthermore, interactions within a diverse development team (engineering, education, outreach, multiple institutions) can create new opportunities for collaboration. Independent efforts have the option to use portions of the materials available for large scale efforts mixed in with locally developed events. The following are examples of events that have been developed for specific locales.

- Gear Up Utah is a 2 day long career fair in Utah, focused on upcoming manufacturing positions. Over 2,000 high school and junior high students from around the state attended in 2008. They participated in such activities as manufacturing plant tours, interactive exhibits, and hands-on activities [Agenda, | Gear Up Utah, 1].
- Michigan State University hosts a two week long residential Mathematics, Science and Technology Program (MST at MSU) for middle school students with technical interests. During their two week stay at MSU, participants will go attend 10 different academic units, each of which includes a brief technical lecture followed by hands on projects and competitive group projects [Rhoads, 6].
- Since 1995, Virginia Tech has been running a one week long summer camp called IMAGINATION for rising 8^{th} and 9^{th} graders. IMAGINATION attempts to entice young students towards pursuing engineering degrees through innovative events such as chemistry magic shows, fire extinguisher training, building bubble powered rockets, and many more. Virginia Tech conducted a survey of participants from years 1995-1998 to see what affect the camp had on the college majors of participants. Of 26 valid respondents, 14 of them were in science or engineering related fields [Sexton, 7].

- Lamar University in Texas hosted a weeklong camp exclusively for high school aged girls in 2009 called gO WEST. During the camp, the girls did activities such as analyzing the mechanics of bicycles, finding ways to recycle umbrella parts, and designing and programming LEGO robots. After the camp, over 75% of the participants indicated that they were interested in pursuing engineering as a career [Aung, 2].
- The School of Engineering, Mathematics, and Science at Robert Morris University has been hosting Manufacturing outreach programs since 2002. They have several different types of programs including "Expanding your Horizons" for 6th-9th grade girls who display an interest in STEM fields. This program focuses on hands-on workshops led by women scientists, mathematicians and engineers, with the goal of giving the girls new role models. After the program, 71% of the girls indicated that they were more interested in math and science. This program has reached 551 attendees in that past 2 years alone [Erevelles, 4].
- The Jim Wentz Manufacturing Camp is a week long summer camp held at Stanley Community College in North Carolina. The middle school students attending the camp learned circuit design, theory, and construction through utilization of electronics automated design computer software called Multisim [Stanly Community College marketing, 9].

All of the most successful engineering outreach attempts try to involve kids directly either through competition, hands-on activities, or both. Reviews and evaluations of some of the programs specifically note that even as little as a 20-minute lecture period may be too long and turn kids away from the material [Rhoads, 6]. However, the programs that do have formative evaluations appear to have a very positive impact on the students likelihood to pursue a STEM related career [Sexton, 7].

For many more examples of K-12 Outreach Programs as well as common practices and themes, please see "Understanding K-12 Engineering Outreach Programs" by Jeffers, Safferman and Safferman [Jeffers, 5].

CAMP ACTIVITIES AND TOURS

The first two camp days included activities and tours, and additional activities were completed on day three. We chose to have the activities in the mornings when we hoped to have higher levels of camper attention. Tours of manufacturing facilities were considered active enough to maintain attention levels during the afternoon.

Camp Activities

Two of the four Techfacturing camper groups met in the Manufacturing Engineering Technology (MET) lab on the BRCC campus. In one group, the 'World of Energy' was studied including the basic laws of Thermodynamics, what electricity is and how it is produced along with the study of 'state' changes of materials such as occur in a direct expansion refrigeration systems and evaporative cooling. Lab exercises included learning how to use a 'multi-meter' allowing the students to measure the voltage outputs on eight different types of batteries as well as making chemical batteries out of lemons and potatoes using zinc nails and pennies. By using three of these 'eatable' batteries in series, a calculator was powered with a max voltage generated being 3.2 volts. Through the use of an infrared sensor, different light bulbs were tested to find the most efficient type of lighting as well as understanding evaporative cooling on a 'black body' cloth with various liquids tested having different vapor pressures on the temperature of the cloth surface. The students left the Manufacturing Engineering Lab at BRCC understanding energy is not 'free' and the need to conserve and use it wisely.

Students in the second group at BRCC were given a short introduction to CAD and solid modeling using SolidWorks software. The classroom was setup such that each student could operate their computer while also seeing a large-screen projection of the instructor's computer. The students followed instruction and examples from the instructor to learn the basics of solid modeling by building a basic six-sided gaming die. These basics included sketching of shapes, extrusion of sketches to produce solids, and extruding cuts into existing solids. Students also learned how to zoom and pan around their models and how to add fillets to sharp edges. Each student was able to personalize their model by giving it color and texture using the various software tools. Finally, students were able to print a color copy of their model on a large-format printer.

Once the students were working independently on the solid modeling, groups of two or three students at a time were given a demonstration of a CNC router in the adjacent lab. The group was able to assist in clamping down wood blocks onto the table of the router. The instructor worked on the computer with each student to design a layout with their name that would be cut into the wood blocks. The students then watched as the router cut their pattern into the wood block.

The remaining two groups met at James Madison University and participated in "Destination Imagination" (DI) style collaborative design challenges.

> Destination Imagination provides a broad range of exciting, "hands-on and minds-on" experiences that teach creativity, teamwork, and problem solving and provide real-life opportunities to apply them. These experiences are designed to move beyond the rhetoric and meet the challenge of providing all young people the opportunity to learn the basic skills of the 21st Century[Destination Imagination, 3].

DI publishes activity ideas along with a list of required materials. The activities we chose for Techfacturing Camp typically required students to work in groups to design and construct a device to perform a specific task. Figure 1 shows a group of students working together on a typical DI activity.

Figure 1: Students work on a bridge for marbles

The materials provided were simple: paper clips, Popsicle sticks, paper plates, sticky notes, etc. We selected to use some of the published DI activities as well as similar activities that we developed for Techfacturing and other outreach events. The DI activities we prepared were:

- Slip and Slide the Divide: students build a structure to direct marbles into a receptacle
- Waller Coaster: students use sticky notes to direct a marble along a path
- Students build a container to hold straws upright
- students create a wind powered device
- students build a bridge to support marbles using various materials

We also prepared similar activities that we developed ourselves such as:

- Golf ball support: students use materials at hand to support a golf ball, the object is to have the golf ball supported as high off the work surface as possible
- Softball support: similar to the golf ball support
- Soft Landing: students construct a glider to soften the landing of various payloads

Each of the above can be readily turned into a competition by assessing points for achieving various goals. This can be as simple as assigning one point per inch of elevation of a golf ball, or can be more complex to promote consideration of design tradeoffs. For instance, during the Soft Landing activity students built a device designed to give their payload (a pipe cleaner they shaped into a "pet") a soft landing when dropped from a fourth floor mezzanine. Figure 2 shows two members of a team preparing to test their device.

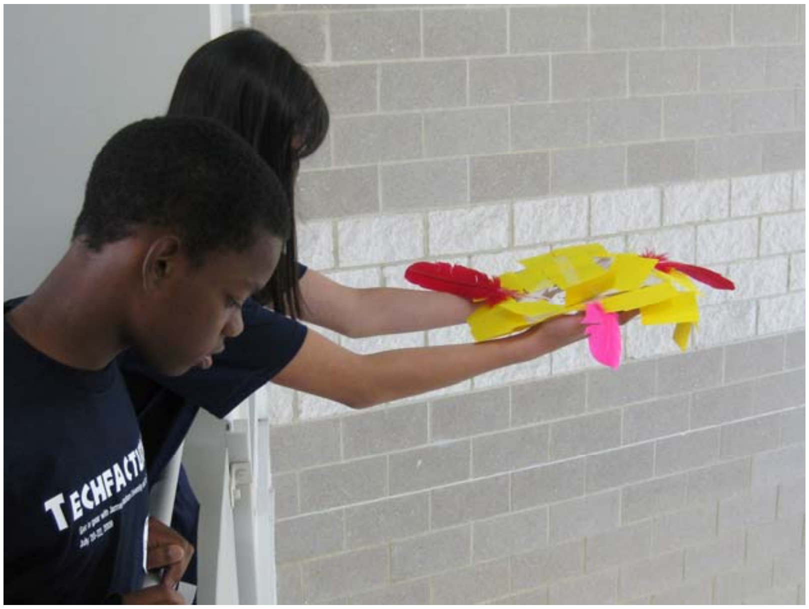

Figure 2: Students prepare to release a Soft Landing device

Each team started with the same materials: 3 feathers, 2 marbles, 26 note cards, and one roll of tape. Scoring was as follows: each device was given a material score based on the materials used: 3 points per feather, 10 points per marble, and 1 point per note card, the materials score was multiplied by the time of flight in seconds to produce the team's final score. A team's time of flight score was taken as the average of five drops, we required teams to retrieve their own devices using the stairs in order to get them to expend some energy. Average times of flight were calculated by each team on a chalk board. Figure 3 shows a "soft landing" device on it's way from the mezzanine to the floor far below.

Figure 3: Activities such as Soft Landing that require movement outside of the classroom tend to keep campers engaged

Plant Tours

BRCC faculty members have developed relationships with a number of manufacturing facilities in the Shenandoah Valley. We were able to schedule tours at four of these facilities. Each group of campers toured two of the four facilities. The facilities can be categorized as snack production, circuit board production, and blade production facilities; students were especially interested in the snack production facilities. A one hour time slot was assigned for each tour along with an additional hour for round-trip travel. As a rule, the people that interacted with the students at the plant facilities were enthusiastic about their presence and welcomed them. It was not uncommon for upper level management at the facilities to stop in to greet the students. Students were encouraged by their tour guides to ask questions along the way; either of the tour guide or of people working in the plant.

On the mornings of days two and three the activity session started with a ten minute recap of the previous day's tour to determine what students had taken away and to imprint one or two themes. The recap started with simple questions such as:

- Where did we go?
- What did they make there?
- What jobs did you see people doing?
- What do those people have to know to do their job?
- Where did they learn that?

Site specific questions were also asked such as:

- Why does a particular manufacturer use robots?
- What does IP (intellectual property) stand for?
- What does SPC (statistical process control) stand for?
- Why is [intellectual property or statistical process control] important?

This also allowed the faculty to selectively reinforce different aspects of the tour.

EVALUATION OF TECHFACTURING

The response of campers and their parents to surveys along with observations of the camp developers provides the basis for evaluating the first Techfacturing camp. Survey results are shown in tables 2 and 3.

Table 2: Results of Camper Survey (5 Point Scale)

Question	Average Response
The activities I did were fun.	4.3
I would recommend Techfacturing to my friends.	4.1
My teacher gave us lots of hands-on activities.	4.4
I learned a lot.	4.0
I would like to come back next year.	4.0
Overall average	**4.2**

Students were overall very pleased with the camp, rating it an average of 4.2 on a 5.0 point scale. Naturally, the tours of the snack production facilities were the most highly rated activities, but students provided plenty of other comments and feedback as well on other aspects of the program. Some comments provided by students:

- "I really liked seeing the connections between the activities and the actual factories."
- "Everything we did helped me understand."

The one disappointment consistently mentioned by a significant number of students was that only half the students had the chance to visit a snack production facility due to travel time and location.

Table 3: Results of Parent Survey (5 Point Scale)

Question	Average Response
I am pleased with what my child has achieved and learned during Techfacturing.	4.7
I would recommend Techfacturing to other families as an enrichment activity for their children.	4.8
The registration process for Techfacturing was straightforward and clear.	4.4
The instructor for my child's Techfacturing activity worked well with my child.	4.7
The amount of material covered was appropriate for my child's age and ability.	4.7
Overall average	**4.6**

Parents were also very pleased with the camp, rating it an average of 4.6 on a 5.0 point scale. Parents were pleased with the learning their children demonstrated, and the opportunity to interact with other children and with faculty. Parents and children alike both wished that the program would be longer, possibly a week instead of three days. Some comments provided by students:

- "To see how things are made and the time it takes to make things happen is extremely valuable."
- [I loved] "the excitement he had in the evening telling me where he'd been that day. I could tell he had a good time."
- "My child enjoyed seeing the plants – seeing science and math in action. She also loved the activities (problem solving, etc)."

Observations of Camp Developers

The following observations were made by faculty and student helpers during and after Techfacturing camp and are related to the activities, tours, parental visit, and the collaboration between entities.

- Activities
  - Students worked in group sizes that ranged from three to eight; more students seemed to be engaged when there were three students per group.
  - Younger students seemed to take the challenges more seriously and it seemed best to group them together. Some older students spent a significant amount of time trying to "game" the rules rather than engage in collaborative problem solving.
  - Best results were achieved when each group was assigned a "minder" to keep them on track. It is important that minders do not help provide solutions, although they may ask leading questions. This is more natural for college students in education programs since engineering and technology students tend to want to help solve the problem.
  - Activities that promote motion seem to work the best. For instance, when teams build a device and then test it in some other part of the building
- Tours
  - Students appeared to enjoy the tours although it was difficult to judge their level of engagement in the technical content of the tours.
  - The tours were an excellent opportunity for engineering and technology faculty and students to see the inside of local plants, and to make connections with people at these plants.
- Parental visit and report-out
  - Parents enjoyed seeing pictures of their children in power point presentations although not all of the camp students were thrilled to present.
  - Best practice for this appears to be a short instructor led group presentation that includes a lot of pictures of camp students engaged in activities.
- Collaboration
  - Collaboration across institutions and entities within institutions can be rewarding for Camp developers since it creates opportunity for new connections to be made.
  - Broad collaboration also can generate confusion and miscommunication. Care must be taken to remain flexible and to maintain open lines of communication.

These evaluations from parents and students, as well as the observations of camp developers and staff, together contribute to the development team's understanding of the success of programs of this nature. Overall, Techfacturing was a great success, and parents and students were pleased with the experience. Many of the students grasped the connection between their morning activities and the physical experience of touring the plants and seeing manufacturing in action, and parents appreciated these connections as well. Faculty at both institutions had the chance to build relationships with their counterparts, which creates valuable future collaboration opportunities.

Recommendations for Future Camps

The Techfacturing development team met after the close of Techfacturing camp to discuss the survey results and to compare observations. This resulted in the following recommendations for future iterations of Techfacturing.

- Include breaks
  - On the first day we noticed that students grew restless after two hours, many students requested a restroom break or asked if they could go get a snack from the vending area. On the second day we built in a break time so that all the students could do these things at a prescribed time.
- Increase student engagement during tours
  - In order to enrich the campers experience we intend to promote active tour participation in order to get students to observe specific things. This could take the form of a "scavenger hunt" check sheet for each plant.
- Add a follow-up component; use contact information (with parental permission) to follow-up with students some time after completing the program to determine whether their interest in STEM-related activities and future pathways had grown or changed.
- Collaboration
  - Although many student activities were "canned" DI activities, or custom activities inspired by DI activities, the activity sequence and schedules were determined by instructors from technical fields. It was noted that future iterations should include the input of education graduate students in the development of the activities, their sequences, and schedules.
  - Include a training day to allow faculty and college students to work through the activities and perhaps recommend changes before the camp starts. This would also give the camp staff an opportunity to get acquainted.

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Sarah MacDonald

Sarah MacDonald serves as Program Coordinator for Outreach & Engagement. She came to JMU in July of 2007, and is responsible for coordinating multiple aspects of events and programs for Outreach & Engagement, including marketing, communications, and logistical arrangements. She holds a Bachelor's degree from Blackburn College, and Master's degrees in English and Human Resource Education from the University of Illinois at Urbana-Champaign.

James Leech

Received a B.S. from Virginia Tech in 1972 in Industrial Technology with additional study in the areas of Project Management, Economics and Environmental Science. After thirty years in manufacturing as a manager and engineer in various disciplines, Jim retired from his role as Senior Process Engineer for *The Hershey Company's* Virginia plant in Stuarts Draft, VA. In 2003 he became an adjunct instructor at BRCC, where he began work on developing the *Manufacturing Engineering Technology* program of which he is now Program Head. The program offers an AAS in Technical Studies with emphasis on *Manufacturing Engineering* which includes areas of study in fluid mechanics, electrical theory, PLC programming, industrial controls, automation systems and engineering economics. The program was developed with strong input from business and industry within the Shenandoah Valley which comprises the majority of the Technical Studies Advisory Board for the College of which Jim is the Chairperson.

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Lester Smith is Director of the Blue Ridge Tech Prep Consortium and BRCC's 2m dollar U.S. Department of Labor Community Based Job Training Grant. He earned a bachelor's degree in education and business administration from Eastern Mennonite University and graduate work in administration and adult education at Virginia Tech. He began his career as an Industrial Cooperative Training Teacher at Broadway High School. He then became the Director of Continuing Education and Apprenticeship at Massanutten Technical Center where he was responsible for the administration of these programs. Currently, Mr. Smith directs the Tech Prep consortium where he provides career development activities for students and teachers.

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