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Using Themes Such as Motorsports as an Avenue to Incorporate Science, Technology, Engineering, and Math (STEM) Into Classrooms

Tyler Agan
California State University, Monterey Bay

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Using Themes Such as Motorsports as an Avenue to
Incorporate Science, Technology, Engineering, and
Math (STEM) Into Classrooms

Tyler Agan
Fall 2015

Senior Capstone Advisor: Dr. Paoze Thao

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Abstract

Motorsports are often viewed in the public eye as a dangerous, boring, and wasteful sport that provides little benefit to society. In an era where the United States leads in innovation but is behind in Math and Science test scores, new ideas and methods need to be introduced. This senior capstone research project examines how Motorsports could serve as a theme for teaching Science, Technology, Math, Engineering (STEM) subjects. The STEM Education platform provides a new way of thinking for students who need something different in order to learn. This project explores the relationship between the exciting world of Motorsports and STEM subjects with surprising results. The results reveal that themes such as Motorsports can be used as an avenue to incorporate STEM in the classrooms.

Introduction and Background

In today's world of standardized testing, high-class sizes, and complicated common core curriculums, innovation and creativity must be utilized in order to achieve growth. In a time where the United States is the leader in technology, but ranks 25th in Math test scores and 17th in Science test scores, new creative methods are needed to engage and challenge students while keeping learning fun and productive. (Chemi, 2014). This is where STEM (Science, Technology, Engineering, Math) Education enters the fray. STEM Education is a relatively new education initiative that addresses the need for America's students to improve in Science and Math. The STEM subjects are everywhere in society which provides the unique opportunity to use interesting themes such as sports or video games to encourage students to engage in the content. If the students are engaged and having fun they are most likely learning and building their knowledge. An Elementary school teacher that I interviewed stated, "STEM makes it more interesting and therefore more engaging for the students by closely simulating real world applications and core academic subjects." (Personal Interview, October 20, 2015). In a National Education Association Today magazine article, a Sixth grade teacher named Robin Meade says, "When teachers give students some encouragement, it can be a powerful thing." (Hawkins, 2015, p. #60).

The reason I chose this topic simply to investigate if I could bring my two passions together. I currently race go-karts and have for the past 13 years with great success and wish to bring those experiences to my future classroom. The broader issue is whether or not Motorsports as a theme is viable in elementary school curricula.

While researching STEM Education, the thought occurred to me if I could take my passion, Motorsports, apply it to STEM Education, and then bring the results to my future classroom. I wanted to see if it was possible to teach any level of Elementary education with a motorsports themed STEM curriculum or unit. I found that it is very much possible. In this paper I will explain what motorsports are, why the Motorsports industry is viable and important, go into more detail on what STEM Education is, and describe how the two work very well together. You will also see what the pros and cons of my idea are and if it is a viable method to teach students with.

Literature Review

As mentioned in my introduction and background, Motorsports are a passion for me. I'm fortunate enough to be employed in the Motorsports industry. There are a variety of topics that must be addressed in order to bring Motorsports and STEM together. The literature review portion of my capstone project addresses what Motorsports are and what they offer in addition to STEM education and how the STEM subjects are utilized in Motorsports. My primary research question was, "How can Motorsports be incorporated into the classroom by using Science, Technology, Engineering, and Math (STEM)?" I also address the pros and cons of my theory that were realized through personal interviews and introduce two popular programs for STEM education.

What Are Motorsports?

The first topic I must address is what motorsports are. Many people are unaware of motorsports and what they even are. Motorsports are simply defined as "a sport

involving the racing of motor vehicles, especially cars and motorcycles.” (Oxford, 2015). According to a report written by William Lawhorn, the first recorded automobile race took place in Illinois in 1895. The cars were very slow back then because the 54-mile course took 10 hours for the winner to complete. There are 4 different forms of tracks or circuits in motorsports. Oval tracks are tracks simply oval or circle shaped and range in length from a quarter mile to two and a half miles. Usually the faster the cars are, the bigger the track they race on. Road courses are longer courses with both right and left hand corners. Subcategories of road courses are street courses. Street races are not the illegal races people take place in to see how has the faster car, but events often taking place in big cities. The two most famous street races in the world are the Formula 1 Grand Prix of Monaco and the Indycar Grand Prix of Long Beach. Every year a portion of the streets of Long Beach, California and a portion of the Streets of Monte Carlo, Monaco are shut down and turned into a racetrack which results in incredible sights and sounds. The third category is drag racing, where cars race down a straight track an eighth or quarter mile long. Last but not least is rally or hill climb courses. These are much like road courses, but rally/hill climb courses do not share a start/finish line. The start line and the finish line are often miles apart.

Motorsports are prevalent in most industrialized nations, but each nation has its favorite form. People in the United States who don't particularly follow any motorsports think of NASCAR when car racing is brought up in a conversation. NASCAR stands for National Association of Stock Car Auto Racing and is the most popular form of motorsports in the United States. There are the previously mentioned stock cars that are based upon sedan showroom models such as the Toyota Camry, Ford Fusion, and

Chevrolet SS. They vary from cars that are minimally modified to cars that are custom built and share nothing with the showroom car besides the shape of the body. Stock cars mainly race on oval shaped tracks rather than road courses. Next on the list of motorsports categories are sports cars. Sports cars are usually upscale, high performance based cars such as the Audi R8, McLaren 650s, Chevrolet Corvette, or Bentley Continental and only race on road courses. These cars are usually more technologically advanced than stock cars and are faster on road courses because of their weight and agility, but slower on ovals because they have less raw horsepower. Sports cars are popular around the world because of their road relevance. Manufacturers form race teams to try and improve on their car on the track, then apply that knowledge to the road car.

Also popular in the United States is a series called Indycar. The Indycar series' biggest race is the world famous Indianapolis 500. Indycars do not look like anything that is driven on the street because of their shape. They are referred to as "single seaters" because of the small, narrow, lightweight, and open cockpit like structure. Imagine a fighter jet on wheels but with no cover over the pilot's head. They have aerodynamic structures called "wings" on the front and rear of the cars in order to create downforce. Downforce will be discussed further on in the paper. Because of this downforce and lightweight, Indycars are some of the fastest cars in the world, reaching top speeds of 235 miles per hour at Indianapolis Motor Speedway, a 2.5 mile oval. The other open wheel category is called Formula 1. Formula 1 is the most popular motorsport category in the world. It is often described as "the pinnacle of motorsports" because Formula 1 cars are the fastest racecars in the world, excluding drag racing cars. Formula 1 arguably has the best drivers and race at the toughest and most glamorous tracks in the world. Formula 1

cars are the most capable cars in terms of lapping a circuit, or course, the quickest. There is nothing faster around a road course than a Formula 1 car. Last but not least are the prototypes. Prototypes are quickly becoming as popular as Formula 1 because of their sheer speed, capabilities, and technological relevance.

The top class in the Prototype series is called LMP1, or Le Mans Prototype 1. Le Mans refers to the 24 Hours of Le Mans, one of the biggest and most important races in the world that takes place in Le Mans, France every year. Modern LMP1 cars are hybrids, meaning they have a normal gasoline engine and an electric engine that work together to provide enormous levels of horsepower. When those levels of horsepower are planted in a lightweight car with large amounts of downforce, and the most advanced technology available, amazing things happen. Le Mans is currently known for being a showcase for new and innovative technology where other forms of Motorsports aren't.

There are other forms of motorsport that are not as mainstream as car races, such as drag racing, motorcycle racing, airplane racing, boat racing, and go kart racing. Drag racing is simply about speed. The track is usually $\frac{1}{4}$ mile long and has two lanes, one lane for each car. There is what is called a "Christmas tree" with a series of lights at the beginning of the track. When the green light comes on, the race is on. Whichever car reaches the finish line first wins. The top level of drag racing takes place in the NHRA (National Hot Rod Association) and features Top Fuel cars. Known for their long, narrow body and their fighter jet like cockpits, Top Fuel cars use engines that make up to 10,000 horsepower, which would be the equivalent horsepower to 1,000 Honda Civics. They travel to speeds up to 330 miles per hour, and only in a quarter mile distance. What makes Top Fuel dragsters so amazing is chemistry and physics, but I will save that for the

science section of this paper. Motorcycle racing is another popular, yet unknown form of racing. Whether it is a dirt bike or a street bike, millions around the world watch and participate in motorcycle racing every weekend. What makes motorcycle racing so interesting is the danger aspect. Watching riders travel 200 miles per hour on a motorcycle or watching a dirt bike racer jump a 75-foot gap is an exhilarating experience. Airplane and boat racing are the two smallest forms of motorsport, mostly because of the availability. People around the world can drive their own cars on a racetrack or ride their dirt bike on their property, so car racing and motorcycle racing are relatable and cheaper. Most of the population cannot fly their plane or go boating, so the interest in racing them is lower. With lower interest comes less people watching, and with less people watching comes less money involved, and with less money comes less growth.

Last but not least is go-kart racing, or karting. Karting is important because it is the stepping-stone to car racing. This is where youth and motorsport meet because kids as young as five years old can start racing. They can work their way up through the age groups and eventually land in what is called a shifter kart. Shifter karts are extremely quick because of their power to weight ratio. This will be explained more in the math section of this paper. The only vehicle that has a better power to weight ratio is a Formula One car. Because of this, younger kids can develop into top-level drivers and move onto cars. Besides developing future world champions, karting is important because it provides relatively easy access to competitive racing. Racing cars is very expensive depending on the level and the car, but karting is much cheaper. A college student can scratch his competitive itch by spending a few thousand dollars and heading out to the local go-kart track. A father and son can spend time together and develop life skills and

skills to take to school. What are those skills? Hard work, determination, respect, mechanical ability, and critical thinking are very important in both motorsports and real life.

Why are Motorsports Important?

Motorsports are often thought of as pointless, dangerous, and unnecessary. While this opinion can be understood, the reasons lie deeper than what is seen on the news or media. Much like Football or Baseball, the only time motorsports are mentioned on the nightly news is if something tragic has happened, which often gives the uneducated public a bad taste in their mouth. The main reason why motorsports are important is because of the opportunity to improve technology and further development in many different areas, including alternative fuels, tire technology, safety improvements, engine efficiency, aerodynamic efficiency, and integrated technology. We can make gains in these fields while enjoying a sport. These improvements are taken by the manufacturers from the racecars and applied directly to the road car counterparts. In the article “15 Ways the Indy 500 changed the way you drive”, (Swift ,2011) motorsports legend AJ Foyt says, “It’s made American cars perform a lot better. We put it way over the line at Indianapolis, so if it works there, it’ll work on the highway.” Fellow legend Andretti says, “At Indy, we are the NASA for the production-car world, and that is clearly why manufacturers are involved-it’s such a good test bed.” (Swift, 2011). An example of an Indy 500 innovation is the first use of the rear view mirror. The first recorded use of the rear view mirror was in the first annual Indy 500 in 1911 by driver named Harroun. It was highly controversial at the time because he could use it as an advantage to see behind

him and the other drivers could not, and because of that he did not need to carry a co-driver with him, which allowed him to drive a smaller car that was more efficient. Because of this, he won the race. It was seen as a great idea and was marketed as an aftermarket device for cars in the mid teens. (Swift, 2011). Another fascinating invention that came from the Indy 500 is the seatbelt. In 1922, a driver named Barney Oldfield decided to install seatbelts made of parachute material. At this time, seatbelts were not mandated and were never even an idea. Barney was tired of seeing other drivers being killed because of being ejected from their car, so he made the upgrade to his car. (Swift, 2011). Since then, seatbelt technology has come a long way and is not even a second thought, all thanks to Barney Oldfield and motorsports.

Apart from the mechanical reasons that make motorsports important, there are personal reasons that make motorsports important. As previously mentioned, millions of people around the world watch motorsports religiously. While a concrete amount of viewers cannot be calculated, an estimated 425 million people worldwide watched the world's most popular form of motorsport, Formula 1, in 2015. According to an NBC Sports article, numbers are currently falling due to lack of interest, but reached an all time high of 600 million in 2009. (Smith, 2015). Domestically in the United States, Nascar averaged 5.8 million viewers per race in 2013, while it averaged 8.4 million viewers per race. According to a Forbes article written by Darren Heitner, it is estimated that close to 75 millions people in the US are Nascar fans to some extent. (Heitner, 2012). What do these numbers mean? It means that businesses can place their logo on racecars as a form of advertisement.

Advertisement and sponsorship is a major part of the motorsports industry and many companies count on it in order to grow. According to a Nascar.com article, one in four Fortune 500 companies used Nascar as a part of their marketing campaign in 2013. Steve Phelps, Nascar's chief marketing officer, says, "There's a reason the number of *FORTUNE* 500 companies invested in NASCAR remains higher than any other sport. Our fans are among the most brand loyal in all of sports. Some of the world's biggest, most recognizable and profitable brands utilize NASCAR as a critical and powerful part of their marketing mix because it works for their business." (NASCAR, 2013, p.#1). In the Forbes article written by Heitner, it is said that Mars Incorporated, the company that makes M&M's, received a 4 to 1 return on their investment for their sponsorship of driver Kyle Busch. A typical Nascar season budget is anywhere from 10 to 25 million dollars, so Mars is making a large sum of money just for marketing candy by using Kyle Busch and his car. (Heitner, 2012).

In addition to the road car advances and business opportunities that motorsports provide, there are many job opportunities in the motorsports industry. Due to the many different tasks needed to make a team successful, a vast variety of different skills and expertise is needed. Typically a team has engineers who handle making the car as fast as it can go while being efficient over a race different. The engineers, also called crew chiefs, need a pit crew to preform tasks. Pit crew members perform mechanical duties such as making physical adjustments on the car and fixing damage. While the race is happening, they service the car during pit stops. Typically there are two to four tire changers depending on the rules of the sanctioning body. The crew members must carry the new tires to the car, take the used set of tires off, and then put the new tires on the car

as fast as they can. In addition to tires, there is a gas man who is responsible for refueling the car and a jack man to lift the car off the ground so tires can be changed. In addition, there is one crew member that cleans the grill of the car, the windshield, and tends to the driver if needed. A typical Nascar crew is made up of two tire carriers, two tire changers, a jackman, a fuel man, and a utility man, or seven crew members total. In addition to the actual pit crew, there are crew members behind the wall. Usually teams have two to three engineers, a tire specialist, two tire assistants, and a fuel assistant to perform duties in order to aid the pit crew. The pit crew must be ready at any time in case the car has trouble on track.

How does this make racing important? Usually there are anywhere from 43 to 50 teams participating at any given Nascar race during the 38 week season. If 43 teams have 11 to 12 crew members, there are a total of 516 crew members working at every single race. In addition to the Nascar Sprint Cup Series, there is the Nascar Xfinity series, the Triple A series to the Sprint Cup Series and the Camping World Truck Series. There are typically 40 teams racing in the Xfinity Series and 36 in the Camping World Truck Series that have the same amount of crew members as the Sprint Cup teams. There are approximately 440 crew members working during every race of the Xfinity Series and approximately 396 working during every Camping World Truck Series race, which means approximately 1,355 crew members work during Nascar races every weekend of the schedule.

In addition to the crew, there are the people behind the scenes. These people work for the drivers, such as driving their bus, taking care of their personal appearances and press duties, or physical fitness. Some drivers hire their own people for these duties while

others have their teams take care of everything. There are the thousands employed by the track to perform tasks such as selling food or tickets to being in charge of the track itself. There is the TV crew that brings the races to the fans and the hundreds of members of the media that cover the sport every weekend. Often forgotten are the employees of the team's that do not travel to races. These people only work at the race shop. They fabricate cars, find ways to improve the horsepower of the engine and other working parts of the car, and orchestrate the business side of the team. The business side of the team finds and takes care of sponsors that the team has. It is rare that a team is never looking for new sponsors or partners to bring money into the team. The more money a team has, the more likely they are to succeed. Simply put, there is a place for everyone. Local Motorsports professional Merrill supports this by saying, "Motorsports is multifaceted. From a triathlon-fit athlete to a collegiate scholar, there is a place for everyone in motorsports. It is well and truly a team sport, but unique to motorsports is the scientific element. It is not simply about maximizing an athlete's performance, but rather marrying that maximized athlete with a optimized machine. It takes a massively diverse and skilled group of people to make a successful racing team." (T.Merrill, Personal interview, November 5, 2015).

Women and Minorities in STEM and Motorsports

Motorsports is often viewed as a man's sport, but the truth is women are just as included as men. Everyone knows Danica Patrick, the most famous female driver in the world, but not everyone knows about the popular female engineers. Perhaps the most famous female engineers in the world of motorsports is Leena Gade. Gade is a lead engineer for the Audi factory endurance team using the Audi R18 Hybrid. These are the

extremely fast prototype cars that were explained earlier in the paper. Gade has won the world famous 24 Hours of Le Mans endurance race in France three times, which is extremely impressive. Gade says, “My interest in engineering came first, and it started when I was quite young. To kill time, my sister and I would pull things in the house apart and put them back together again. Just kind of out of boredom, I guess. We moved back to the U.K., and that's where my sister got hooked on Formula One. And through her, having watched it on the TV, I got interested, and I guess the next thing that happened was we realized you could have a career in engineering in motorsport based around just what was going on on TV. The commentators gave a lot of information on how a Formula One team runs, what kind of engineers they have, where the technology is applied. That's really how it came about.” (Pedley, 2015, Pg. 1). The interviewer then asked Gade what it is like to be a female engineer in a male dominated industry and she said “I only realized, I guess, after the first win in 2011 how much of a big deal it was to the outside world. And I guess that's because the stereotypes that exist in motorsport mean that most people would wonder why you would want to do this anyway, which I can partially understand. What I struggle to understand most of the time is the fuss that's around me because I'm just another one of the team. I'm not more special than anybody else. I just happen to be female. At the same time, I can also understand that with the sport itself being male-dominated, it's difficult for any woman to break into it, whether it's in engineering, being a mechanic, being a driver, even being on the operational side of it, being team managers, technical directors, anything really. If you can come into a sport like this, into an atmosphere like this, people stick together a little bit and you have to come in and merge into their circle and that sometimes can be a bit tough, but nothing I

find daunting.” (Pedley, 2015, Pg 1). Other examples of women in motorsports include Kate Gundlach, who is an engineer for winning Indycar team Chip Ganassi, and Andrea Mueller, who is an engineer for Team Penske in the Nascar Xfinity Series. (Fabrizio, 2015, Pg. 1). People who make the calls in motorsports want the people who will do the best job, regardless of gender. This is important because females are underrepresented in the STEM fields. The United States Government is looking to increase the amount of women in the STEM fields. President Obama said, “One of the things that I really strongly believe in is that we need to have more girls interested in math, science, and engineering. We’ve got half the population that is way underrepresented in those fields and that means that we’ve got a whole bunch of talent...not being encouraged the way they need to.” (Obama, 2013, Pg.1).

Also pointed out by the Government is the need for minorities in STEM education. Motorsports serves as a great tool to show minorities that there is a place for them because of its worldwide presence. There are no minorities when it comes to nationality or race in Motorsports. Motorsports are popular in countries such as Mexico, India, China, and Japan. They are also gaining popularity in Middle Eastern countries such as Abu Dhabi, Bahrain, Qatar, Azerbaijan, and Egypt. There are currently drivers at the top levels of Motorsports from countries such as Mexico, Brazil, Japan, China, and Abu Dhabi. Three time and current Formula One world champion Lewis Hamilton is black and comes from a poor upbringing in England, which provides inspiration that anyone can achieve the ultimate success in Motorsports. Motorsports has a place for anybody who has the desire to learn STEM subjects or wants to become a racecar driver.

Pros and Cons

While many of the pros of introducing Motorsports as a method to teach STEM have been outlined in this paper, there are cons. Perhaps the one reason why this may not be a viable strategy to teach STEM to every student in the class is because not every student may have an interest in Motorsports. A successful classroom should have something for everyone to relate to and be inspired by. While Motorsports can act as a source inspiration to learn, it is not a magic potion that will intrigue everyone and raise test scores. Another con of STEM education in general is the costs involved. While a teacher can get creative to bring lessons to a classroom in order to teach STEM, a proper STEM program can be expensive due to materials. Schools are already struggling for funding and don't necessarily want to spend more on something like a Motorsports themed program. The third con would be teacher training. A Motorsports themed STEM program requires vast knowledge of Motorsports and its idiosyncrasies. Teaching teachers about Motorsports so they could properly teach a Motorsports themed STEM unit isn't the most productive strategy. A more productive strategy would be to give teachers the freedom to design their own specialized curriculum with themes that they are knowledgeable of.

This brings up the question of whether or not there are any advantages or disadvantages to incorporating Motorsports into STEM. The advantages of incorporating Motorsports into STEM are numerous. Merrill (2015) says, "Motorsports is a perfect place to teach students about STEM. The sport is so multifaceted. Every job one can have in the industry requires an understanding of STEM. I would recommend it to any STEM student." He also says, "STEM is important to motorsports for one simple reason:

motorsports is about maximizing performance. The competitive nature of the environment requires an understanding of STEM, and those who have the best knowledge are the ones who are the most competitive. If you want to win, you have to be the best at STEM. If it wasn't for STEM I could not do my job.” (T. Merrill, Personal interview, October 24, 2015). Sweeney (2015) says, “I can't really think of a better model, and I think the success of the Formula SAE programs and the high-quality engineers they are producing is a pretty convincing argument for anyone who disagrees!” (M. Sweeney, Personal interview, 2015) Formula SAE is an extra curricular program that college engineering students can take part in. They must design and build a racecar that competes against other school's Formula SAE programs. It is a method for them to apply what they are learning in class and provide skills that they can take to whatever industry that they choose to enter.

Programs and Resources

Different companies in different industries are actively promoting STEM education and its benefits. This makes sense because of the companies needs. Race teams need workers who are talented with STEM subjects. It is now apparent that motorsports provides an excellent industry for these people to work in and a good teaching tool for students of all ages. The leading automotive/motorsports company that promotes STEM education is currently Mazda. Mazda has a program called R.A.C.E. that travels around the country with its race team. They choose a local school and present their racecar and tell students about STEM and how it is important to racing. Mazda Motorsports president John Doonan says, "We are convinced that our R.A.C.E. program will demonstrate to

students in an interesting, fun and engaging way how science, technology, engineering and mathematics are central to the success of Mazda on the race track and in the marketplace. Our goal is to show students just one example of how exciting problem solving can be in the STEM arena and motivate them to always be curious and open to the possibilities." Mitch Moyer, who is principal of Deland High School in Florida, say's of getting chosen by Mazda, "Anytime motorsports can be linked to science, technology, engineering and mathematics, it proves to be an attention getting combination." (Mazda, 2014).

Chevron is also heavily involved in promoting STEM Education and is just one of many companies who invest in STEM education. Since Chevron is a leader in the petroleum industry, they need the most talented workers who specialize in the STEM categories. Their future workers are current students, so they are choosing to invest in them as well as teachers. They are investing in teachers because students cannot receive quality education without quality teachers. Chevron says, "In 2014, Chevron invested nearly \$95 million in education partnerships and programs worldwide." They also say, "In the United States, our total investment in education has been more than \$140 million since 2010. This work has enhanced the educational experiences of more than 700,000 students." (Chevron, 2015). Teachers around the world can contact Chevron and seek grants in order to better fund STEM Education programs.

Methods and Procedures

As you can see, there are many different aspects to motorsports and what they can bring to the table. The second stage in this paper describes what STEM Education is, why

it can help education today, and how motorsports integrates the STEM subjects using personal interviews and online sources. I interviewed three local Motorsports professionals (see appendix one for interview questions) a STEM focused school principal (see appendix five for interview questions) and four local elementary school teacher (also see appendix five for interview questions).

What is STEM Education?

STEM Education is an initiative that promotes learning of Science and Math and their applications. I interviewed Laura Meusel, who is the Principal of the Herman Intermediate School in San Jose, California. The Herman School is a private school that specializes in STEM. According to Principal Meusel, “there are no actual curricular standards for California. Nothing to support Science. Science teachers are going crazy.” (L. Meusel, Personal interview, October 20, 2015). See Appendix six for interview questions and answers for Meusel. Because of the United States worldwide standing in Science and Math, STEM has become a focus. STEM education is simply defined as “STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy.” (Gerlach, 2012, p. #1). The idea behind STEM is meant to better prepare students of all ages to excel in math and science. If they can excel in math and science, they can take those skills and integrate them in technology and engineering. If the students joining the workforce can bring their skills

and knowledge to the workforce, America's economy is bound to grow. President Obama has been a major supporter of the STEM education while his tenure in office. He is quoted as saying, "[Science] is more than a school subject, or the periodic table, or the properties of waves. It is an approach to the world, a critical way to understand and explore and engage with the world, and then have the capacity to change that world..." (U.S. Department of Education, 2015, p.#1). The U.S. Department of Education says that "Yet today, few American students pursue expertise in STEM fields—and we have an inadequate pipeline of teachers skilled in those subjects. That's why President Obama has set a priority of increasing the number of students and teachers who are proficient in these vital fields." (U.S. Department of Education, 2015, p.#1).

The need for STEM education is clear. According to the US Department of Education, not enough students have access to STEM education or STEM learning experiences and not many students see STEM subjects as an opportunity to springboard their career. (U.S. Department of Education, 2015, p.#1). Also according to the U.S. Department of Education, only 81 percent of Asian-American high school students and 71 percent of white high school students attend high schools where the full range of math and science courses are available. Hispanic, Native American, and other minorities have even less access. (U.S. Department of Education, 2015, p.#1). Minorities are important in Motorsports, which is detailed in a later section of this paper.

The United States Government has mapped out their plan, which is listed on their website, <http://www.ed.gov/stem>. The plan is designed by a committee, called CoSTEM, which is made up of 13 different agencies or companies. These companies include the United States Department of Education and all of the mission-science agencies. These are

the agencies that are working to increase the effectiveness of federal investments in STEM Education. Step one is to improve instruction in preschool through 12th grade. Step two is to increase and sustain public and youth engagement in STEM. The third step is to improve the STEM experience for undergraduate students and the fourth is to better serve groups that are underrepresented in STEM fields. Last but not least, step five is to design graduate education for tomorrow's STEM workforce. (U.S. Department of Education, 2015, Pg.1).

Local Motorsports professional Merrill (2015), says in a personal interview, “STEM is applicable outside of motorsports. A student who is well versed in STEM has many options for applying and succeeding with that knowledge.” (T. Merrill, Personal Interview, November 5, 2015). See appendix two for interview questions for Merrill. The second motorsports professional who I interviewed, Romano, agrees. He says, “Having a basic understanding of the various branches of STEM can help you in many, many fields. I had no idea I was going to fall into motorsports in the way that I did, but with the understanding of STEM I already had (which, coincidentally, much of which I learned from being around racing my whole life), I was able to dive right into managing just about every aspect of the race team I was on.” (N. Romano, Personal Communication, November 11, 2015). See Appendix three for interview questions for Romano.

The STEM Subjects

As already stated, the STEM subjects are Science, Technology, Engineering, and Math. Two of these subjects are building blocks and the other two are where and how to

apply the building blocks, Math and Science being the building blocks and Technology and Engineering being applications. So, what exactly are these subjects?

The first subject in the acronym is science. Science is the study of “the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment.” (Oxford, 2015). Students learn about science to build a knowledge foundation about why Earth works the way it does.

The second subject, Technology, is a subject that isn't as prevalent in public schools. Technology courses in today's age involve computer-based skills. Starting with Kindergarten, students learn keyboarding, how to use various programs including word processing, graphic arts, and photo editing, Internet use and web development, and even simple coding by the time they are in fifth grade. The goal is to have kids that are able to be proficient in, at minimum, operating a computer.

Engineering is the third subject in the acronym. Engineering is defined as “the branch of science and technology concerned with the design, building, and use of engines, machines, and structures”. (Oxford, 2015). The goal of teaching engineering to students is to exercise their creativity, critical thinking skills, and problem solving skills while using the math and science skills they have learned or are currently learning in class. Actually using what is taught in class to produce something other than test results is bound to yield students who have skills when entering the work force.

The fourth and final subject, Math, is the study of numbers, equations, functions, and geometric shapes and their relationships. Math is a very important subject because there are so many aspects of our lives that depend on knowing it at a proficient level.

Engineering cannot happen without knowledge in mathematics and science, and without mathematics, there isn't growth in our society.

This information led me to find out where and how these subjects integrate with Motorsports. When asked if Motorsports could possibly serve as a method to teach STEM, Romano (2015) simply says, "Absolutely. It's like word problems on steroids. Not only is it a real-world application, it's a really really cool one that can be really fun to work through." He continues to say, "Suspension systems are a geometry equation, internal combustion is chemistry, ECUs (ECU is an acronym for Engine Control Unit) and tuning involve complex electronics and programming, etc., and a car on a racetrack is a physics experiment." (N. Romano, Personal Interview, November 11, 2015). Sweeney (2015), who is a current professional racecar driver and race shop owner, adds, "Obviously STEM comes into play every day in motorsports, especially in the shop. Every technique used in the construction and fabrication of a race car is a mix of these four key disciplines. It would be easier to find what we don't rely on STEM for in day to day operations, even the old fashioned techniques we use like welding are constantly being evolved with new equipment from the tech sector." (M. Sweeney, Personal Interview, November 17, 2015). See Appendix four for the interview questions for Sweeney.

How does Science integrate with Motorsports?

Science is entangled in every aspect of motorsports. An anonymous Elementary school teacher, teacher two, that I interviewed says, "Physics and Chemistry, and psychology are all employed to various degrees in Motorsports." (Personal Interview,

October 24, 2015) As I also found out, every STEM subject is intertwined. Math involves Science and Engineering while Technology needs Math and Science. While some science categories do not directly relate to motorsports, such as Earth Science or Biology, but categories such as Physics, Chemistry, and Psychology are heavily involved in Motorsports. Indycar driver JR Hildebrand, who was accepted to Massachusetts Institute of Technology, says, “Physics is primarily about motion, force and energy,” he says, “all things we see daily at the race track.” (Chemi, 2014, p. #1). In another interview with Merrill, it was said, “In order to help the driver understand proper technique and car setup engineering, we have to look at the performance of the car scientifically. Simple things like how temperature affects horsepower and grip or how a particular driving line optimizes grip and lateral g-force all require a basic understanding of science.” (T. Merrill, Personal Interview, November 5, 2015).

The Henry Ford Museum has developed a lesson plan complete with National Science Standards that teaches Physics with Motorsports in mind. The concepts include net forces, mass, acceleration, and velocity, all large factors in Motorsports because speed is what is important. Speed wins races. In order to achieve speed, the driver of the car and the head engineer needs to understand the capability of the car, the tire, and the track. The engineer can calculate how much force needs to be put on the car in order to achieve a certain speed in a certain section of the track in order to achieve optimum lap time. The other lesson in the lesson plan is about work, energy, and power in motorsports. This is important because the designer of the engine needs to determine how much horsepower the car needs to reach a certain speed on the track. Subcategories that are extremely important in motorsports are Aerodynamics and Fluid dynamics.

Aerodynamics are important because air has a massive difference on how well the car performs. Some racecars are built with aerodynamic devices to improve speed. For example, Formula 1 cars have large “wings” on the front and rear of the car. These “wings” do the opposite of airplane wings, which are designed to lift the airplane off of the ground. Wings found on racecars force the car into the ground, which is conveniently called downforce, which basically means the car can stick to the ground better and see increased corner speeds. However, because of these increased forces, the car will be limited to how fast it can go in a straight line. In order to increase the straight-line speed of the car, the car must have less “wing” or downforce, but because it has less downforce, it won’t be able to go around a corner as well. The engineer must find a happy medium to make the car aerodynamically efficient and make the car good enough for the driver to perform well. Fluid dynamics is important because it can help the engineer find aerodynamic deficiencies. The car can be put in a wind tunnel, colored fluid placed on the car, and then a giant fan is turned on to simulate the speed in which the car is traveling. The aerodynamicist can then watch and determine where the car is or is not making downforce and make the necessary changes.

As I promised earlier, what makes NHRA (National Hot Rod Association) Top Fuel cars so amazing is the physics involved. Top Fuel cars travel from standing still to 330 miles per hour in as little as 3.6 seconds. The G forces involved can be excruciatingly painful and are not something that a normal person can handle. A typical run sees a Top Fuel car go from zero to 100 mph in about eight tenths of a second. Keep in mind a Honda Civic goes from zero to 60 in about seven seconds. Those are pretty amazing numbers.

Chemistry is also a largely represented scientific category found in Motorsports. Different types of fuels and tires are tested and tried to find what works best for the conditions. Teams are typically limited to what fuel and tires that they can use, but the technology grows every year. Alternative fuels, cleaner fuels, and more efficient fuels are always improving. Some Formula 1 teams have chemists on staff to produce the best fuel for the engine that they have built. NHRA Top Fuel teams use a fuel called Nitro Methane, which produces an extreme amount of horsepower, but is even more toxic than fuel found at a gas station. It is great for making as much power as possible in a quick period of time, but not for a longer race.

Tires are important because they are the part of the car that actually touches the ground. If a car has the wrong tires, it will not work properly. Usually a team has a choice of what compound of tire they would like to use. For example, in Formula 1, the teams have four choices of dry weather tires and two choices if it is raining. The dry weather tires are the super soft, soft, medium, and hard compounds. They are what are called a “slick” tire, which means there are no grooves like what is on a passenger car. The wet weather compounds are intermediate, which are slightly less grooved and work best in light rain, and wet, which are heavily grooved and best for heavy rain. The teams have a choice of which tire they want to use depending on if the best strategy is to go fast, or to go long distances. The harder the tire, the slower the car goes, but the longer the car can go without making a pit stop, which takes time. Engineers use chemistry to determine the hardness of the rubber, and what temperature it reacts to. Another aspect of the tire that is important is what gas is used to fill the tire with and what pressure the tire should be at. Usually this is done with oxygen, but teams also use nitrogen and helium.

Psychology is an often overlooked part of Motorsports because it isn't obvious to the naked eye. Psychology is mostly important to the drivers and their ability to stay focused, which is extremely important. The crew must also stay focused because one small mistake on preparing the car can cause major issues and be potentially dangerous. It can often be hot and uncomfortable at the racetrack and in the racecar, so fatigue for both the crew and the drivers can set in easily.

To combat this, the crew is in top notch shape and is just as athletic as some drivers and some drivers are triathletes. If a driver doesn't have to worry about his or her fitness, they can focus on their task at hand and physically control the racecar with the preciseness that is needed to be safe. Nutrition is very important for driver because temperatures inside of the racecar can reach upwards of 150 degrees Fahrenheit. If you want to see what that is like, turn the heater in your car to its highest setting and on full blast while wearing a full face helmet and a full jacket and snow pants, plus gloves. Then, drive your car around town as fast as it will go (or not) and try not to crash for four hours. You've now experienced a simulation of what it is like to be a racecar driver, except you are not competing against anyone else and have no contract obligations to fulfill. Racecar drivers need to be inch perfect for the entire time they are on track, whether it be one qualifying lap or 500 race laps.

I personally use science to solve any problems I have when I am racing. In go-kart racing, tire temperature is very important. Typically, the more pressure in a tire the more heat can build. It is the same as cooking something. If my tires have too much heat, they won't work properly. Because I am trying to optimize the handling of my go-kart for as long as possible, a pound of air or nitrogen can make a huge difference. In order for the

tire to be at its optimum, I need to determine what pressure it should be at. For the tires on my go kart, typical pressures range from 10 psi to 15 psi. The colder the track temperature, the higher the pressure I need to use. The tricky part is growth of the pressure. With increased heat comes increased pressure. Due to friction of the tire contacting the track, heat is made. If everything is going smooth, I get a pound or two of growth in every tire. If my go-kart is working best at 13 psi and I want it to be fastest on lap 10 out of 16, I would set my pressure at 12 psi. If I guessed right, my kart will be fastest on lap 10 and stay like that until the end of the race. If I start with too little pressure my kart may never reach the point of working at its optimum, but too much pressure could mean my kart is at its optimum too soon and the tire temperatures are too high, which could cause handling issues. I can also use nitrogen to control the temperature of the tires. Nitrogen reacts to heat differently than air. Because of this, the rate of pressure building is slower. Because the rate is slower, I can start my pressures closer to the optimum, so I can be at the optimum pressure longer. Choosing which gas to use in tires can be the difference between winning and losing. Psychology is a part of racing that I enjoy. I've grown into someone who doesn't like to talk to people before my races, so I am usually quiet through out the race day. Because of this, I have no distractions and can just focus on driving. I've also have grown to the point where I don't give in to pressure from other drivers. I can focus on my own race and not try to hard in order to pull away. I am not pressured into making mistakes, so I can stay calm and execute.

How is Technology involved with Motorsports?

Technology is currently growing in the world of Motorsports at a fast pace. Whether it is the cars themselves or making them faster, tech is driving the sport. Data acquisition and telemetry are a few of the new ways in which a driver and team can better themselves. In an interview with Merrill, who has driven in famous races such as the 24 Hours of Daytona and currently serves as one of the top private coaches in the country, it is said that, “It’s important for us to be able to measure the performance of the driver using data acquisition, which involves lots of math and technology. The on-board computer measures everything on the car that moves and graphs the measures over time or distance traveled so that we can analyze the values and compare them to another driver or session. Primarily we are measuring time gained or lost, but we’ll also measure brake pressure, throttle position, steering angles, engine RPM, line geometry, suspension travel, and of course, speed. We’ll also use the data to monitor the performance of the engine and suspension to make sure everything is operating at optimal performance.” (T. Merrill, Personal Interview, November 5, 2015)

By having a computer monitor all of these aspects of the car, an engineer can make decisions on what to do with the car and the driver can see where they might be able to improve. Telemetry is data acquisition that the team can see live. Only the most advanced racecars have the capability to see this, but it can greatly aid the team in making decisions and potentially helping the driver. Computers are also important in saving the teams time. They can calculate anything the team needs to know very quickly. In the math section of this paper some equations are introduced and engineers do not want to waste time manually solving them. Computers can do it instantly so engineers

can make quick decisions. Hendrick Motorsports, which is a leading Nascar team that houses drivers such as Jeff Gordon, Jimmie Johnson, and Dale Earnhardt Jr, has a program called Ignition, which brings the company's usage of STEM to the forefront on its website. Tom Gray, who is an engineer for the team, says, "I use Science, Technology, Engineering and Math on a daily basis. From crunching data with a computer to designing parts and evaluating performance; those topics are interlaced with almost everything that we do. Computer programming and app development is one area of growing popularity in the sport, so right now there is a lot of focus on that, which encompasses a lot of technology." (Caldwell, 2015).

Another newer use of technology in Motorsports is the use of video. GoPro cameras are relatively cheap and easy to get and are extremely easy to use. GoPro cameras are beneficial to teams because they can watch a replay of what the car was doing. They can even overlay the video with the data they get to see exactly what is happening on track. It gives them a clear picture and the data backs any issues up with numbers.

Another driver and team aid that is being utilized more and more are simulators. A simulator is basically like a video game, except much more accurate. Typically a company, such as the world's largest online simulator community iracing.com, uses lasers to scan tracks around the world. They then build the tracks in a virtual world that can be accessed on any computer at any time. The company also builds extremely accurate virtual models of different cars with data provided by teams that can be driven on the virtual tracks. With this technology, teams can test different settings with the car in any condition, test new parts, teach drivers how to correctly drive the car, and examine or

try out new drivers. The drivers themselves can learn new tracks or just familiarize themselves with the track that's on the schedule next. They can mentally prepare for what is about to be thrown at them. Simulators are valuable to teams because it saves them time and money. In some series, the ability to take the real car to a real track and experiment is not an option, and if it were an option it would be very expensive. They do not want to experiment during race weekends because they want to perform at the optimum level, and experiments don't always work. Most teams and drivers utilize public simulators, such as the Dallara simulators or in the comfort of their own home. Only a few teams in the world have their own simulator facility because they cost tens of millions of dollars to build and develop and they are often private. (Biedrzycki, 2015).

I use technology the same way that these professional teams do, except at a lower level. I have a data acquisition system on my go-kart that tells me a variety of things. I can download the data onto my laptop and see my lines on track and their corresponding speed or level of grip. If I know which of the go-karts chassis settings were different that session, I can compare it to another session and see the difference. I then store those notes in a database and rely on them when I need to make a change. I can also compare other drivers to my data and learn from them, or they can learn from me. I have a gauge on my steering wheel called a Mychron, which houses the GPS sensor that provides the important data, but tells me my speed, RPM, and lap time in real time. I use this data while I'm driving to adjust my lines or pace myself.

How is Engineering is used in Motorsports?

Engineering is possibly the most important aspect of motorsports. Engineers build the racecars and make them go fast as efficiently as possible. They provide what the drivers need, they decide the race strategy, and they make the cars better with the information that they are given. Most of the engineers or crew chiefs in Motorsports have at least a Bachelors degree at minimum in an engineering field. There are even drivers with engineering degrees, such as Nascar star Ryan Newman, who has a Mechanical Engineering degree specializing in vehicle design from Purdue University. Drivers with engineering degrees can often communicate with the team leaders better if they know the concepts of what the car is doing and why. Merrill (2015) said in his interview, “...Through execution, we use engineering and technology to improve the performance of the racecar. Based on driver feedback or data analysis, we can adjust the components on the car to optimize grip. Sometimes we can use the feedback and data to design and implement new components to add to the car to improve grip, horsepower, or reduce drag.” (T. Merrill, Personal Interview, November 5, 2015) Engineers vary from the people who build and develop engines, to people who design and assemble the actual cars, to people who create better materials and composite materials, and to electronic systems, and all of them carry college degrees. Sweeney (2015) says in his interview that, “For what we are aiming to achieve, I feel engineering is probably the most important. Basic engineering principles are what guide high quality production, and all the technology in the world will not result in a good race car if it is poorly screwed together. Science, Technology, and Math are the paths we use to make the components that make

up the various separate systems, but the engineering behind the car as a whole is the key to success.” (M. Sweeney, Personal Interview, November 17, 2015)

Although I do not have an engineering degree, I use engineering ideas to make a basic setup using what I am provided for my go-kart. I can use torsion bars, different axles varying in stiffness, different wheels varying in material and stiffness, different seats that vary in shape and stiffness and mounting position, the width of the front and rear tires in relation to each other, the diameter and thickness of the tubing in which the chassis is constructed of, and that is just the beginning of what I can do. I also have to know how to use my body and inputs in order for the go-kart to react the way I need it to. All of these changes determine how much the chassis or frame of the go-kart flexes. The goal is to get the inside rear wheel to actually pick up off of the ground when going around a corner. That is when the go-kart is handling the best and therefore the fastest.

How is Math integrated in Motorsports?

Math is a critical part of Motorsports because of its relationship to Engineering. Engineers need math in order to do their job. Math in motorsports varies from simple addition and subtraction to wildly complicated and confusing equations, which the technology typically takes care of. Without it the necessary equations, methods are meaningless. Engineers need math for simple conversions, material needs, calculating race strategy, and precise measurement amongst other things. Measurement is extremely important because everything on the car must be close to maximum tolerance. This includes tire pressure, the ride height of the car in relation to the ground, engine tuning, gear ratios, the size of aerodynamic devices, suspension geometry and more. Race

strategy is one of the most important duties of a race engineer and he or she needs to know math to be able to calculate fuel mileage. They need to know how much the fuel tank holds or how much fuel the car is in, how many miles per gallon the car is achieving, how many laps the car can do on a tank of fuel, and even the rate of fuel flow from the tank on the pit wall to the car to determine maximum time that a pit stop should be. They also need to know how much the weight of the fuel will affect the car's setup. There are so many variables that the engineer needs to keep track of and math is how they keep track of those variables. Romano (2015) said in his interview that he uses math "Personally, only in very basic senses. I'll use percentages to describe certain aspects of vehicle dynamics and driving to my students, and I'll occasionally have to calculate gear ratios between transmissions and differentials, or pistons speeds, etc." (N. Romano, Personal Interview, November 11, 2015) Sweeney (2015) says, "Really, the math part of this job is mostly 101 level stuff, and never really gets much past practical algebra and geometry for formulas, but it is frequent and critical! We are often using expensive machines to cut expensive materials that may have a few dozen billable hours into making them by the time you get to your last chance to destroy it with a bad machine input, so making sure your numbers are right is vital." (M. Sweeney, Personal Interview, November 17, 2015)

Math is also used to tune engines. In the book "Performance Automotive Engine Math" written by John Baechtel, a student can learn any math involved in optimizing engine performance. The concepts explained in the book include measuring engine displacement, or the actual physical size of the engine and its components, and measuring the displacement that an engine can produce. Then carburation is explained. This includes

air/fuel ratios, intake manifolds, wave tuning, air capacities and more. Cylinder head measurement and theory are explained, followed by camshaft measurement and exhaust system output calculations. An example of an equation used to calculate horsepower loss would look like: $HP\ loss = (elevation \times 0.03 \times HP\ at\ sea\ level) + 1,000$. To find the Bore of an engine, engine builders or engineers use the formula: $Bore = \sqrt{[displacement + (0.7854 \times stroke \times number\ of\ cylinders)]}$. (Baechtel, 2011, Pg 15-17). Math is also used in finding speed in the car itself, outside of the engine. In John Lawlor's book, titled "Auto Math Handbook", calculations are explained in relation to chassis and the physics side of motorsports. For example, the equation used to find the amount of weight transfer in the car, engineers use: $Weight\ Transfer = weight \times center\ of\ gravity\ height / wheelbase \times g\ force$. (Lawlor, 2011). In order to find the lateral acceleration of the car, engineers use the equation: $Lateral\ Acceleration = (2.0 \times \pi)^2 \times radius / time\ squared$. (Lawlor, 2011). As mentioned earlier in this paper, shifter karts are popular and very quick because of their power to weight ratios. A shifter kart with a driver weighs typically weighs 370 pounds and has 50 horsepower. If I divide 370 by 50, I get a power to weight ratio of 7.4. A modern Formula One car weighs approximately 1,600 pounds and has 600 horsepower, which means it has a power to weight ratio of 2.6.

I use math quite a bit with my own racing. I previously mentioned simple tire pressure calculations, but I also calculate gear ratios, I have to keep track of a variety of different measurements, and I have to be a minimum weight, so I must know what my weight is and keep track of that with the amount of fuel that I use. I also use math while looking at my data acquisition. I look at split times through out a lap and must determine averages to see if a chassis adjustment worked or not. Usually I can tell by what the

standard deviation is. If my lap times are the same and fast and the standard deviation is close to zero, I know that is a good setup. If the lap is a little bit faster but the standard deviation is further from zero, it's not as good. Another huge part of racing at any level is geometry. The angle at which a driver enters and exits the corner is everything because of the way the car must go around the corner. There is a specific path that is the fastest way around a corner, so a driver must know the characteristics of the corner and where he or she needs to enter in order to have the correct exit angle. A driver must also know how a radius works and the shortest way around that radius. I am constantly looking at my lines and seeing where I can shorten my radius or take a shorter path around the corner while still keeping the most amount of speed that I can. I do this by using my data acquisition system by looking at physical speed and lateral acceleration numbers. Higher numbers means more speed and a faster lap time.

Restrictions and Problems

This project had only one major restriction. Because of the uniqueness of the topic, there aren't any reports that specifically address the answer that I am seeking. This project was not to find a definite answer, but to explore possibilities. I had to piece together information on two different topics to hypothetically create a curriculum based upon Motorsports. Luckily I had plenty of information outside of reports and scholarly papers to accomplish this. I feel that my personal interviews brought the project to life and showed the potential for my idea.

Recommendation

I recommend Motorsports as a potential theme to teach STEM subjects. Even though it is not completely viable and will not work for every teacher or student, one can not argue the data I have shown here. There are few topics that integrate the STEM subjects like Motorsports does and because of that there is value. I believe there is value in any theme that students can get interested in and recommend teachers to try and think outside of the box. What needs to be decided is if most of the students and teachers can also use the same theme for the sake of transparency. If a theme can accomplish that, it has a chance of succeeding.

Discussion and Results

With the information that I have gathered, I feel like a classroom at any level can have motorsports incorporated using STEM. Whether it is a Common Core classroom or a STEM classroom, motorsports can be used to inspire, interest, engage, and challenge students. As previously mentioned, I interviewed a variety of teachers, ranging from high school down to elementary. All of the teachers and the principals that I interviewed supported my idea. The Principal of a local school says, “My experience is most kids love STEM type activities in the classroom if done right. This will spark a love of learning that should carry over to other subjects.” (Personal interview, October 2015) Another anonymous teacher says, “I think STEM adds motivation-a reason that they are learning each concept. I believe students would be motivated to learn because they would be interested in the topic.” (Personal interview, October 20, 2015) A local high school teacher said he thinks that STEM is important and motorsports can help because “many

students need the practical application and “hands on” experience that STEM provides. When done well it is a huge asset to student learning and future success. STEM is massively important to all levels of motorsports and can be implemented into curriculum.” (Personal interview, October 19, 2015)

My opinion of using Motorsports as a platform to teach STEM is mixed. As already stated, there are issues with my idea. Between the unlikelihood of engaging a majority of students, high costs of what a curriculum would cost if done correctly, and the inability to coordinate lessons with fellow teachers, a complete STEM curriculum that is 100% focused on Motorsports is not viable. Motorsports can be used to teach STEM, but a teacher will need other platforms in order to get the entire class to learn and be successful. Principal Meusel says, “A Motorsports based STEM curriculum would have to be student interest driven and coordinated with teachers. It would need to be a project for a period of time, but not an entire year and would need to be kid interest driven.” (Personal communication, October 20, 2015) Motorsports will still have a presence in my future classroom, but it won’t be the centerpiece because of this.

I do however feel that every classroom should include STEM education because of the worldwide need for it. Sweeney (2015) sums up my opinion on STEM as a whole. He says, “I would add that regardless of a student’s vested interest in knowing the basics of STEM, our society as a whole needs more people educated in these fields. It feeds our industries, it drives innovation, and it means less people mixing bleach and ammonia while cleaning. These are all good things. Regardless of what these people do for a living, a society that understands the value of the scientific process, the benefit of making decisions based on data, and sees that the benefits of investing in STEM projects are

manifold and unpredictable is a society that can adapt to whatever the future looks like.”
(M. Sweeney, Personal Interview, November 17, 2015).

Conclusion

This project taught me so much about motorsports, how curriculums work, and what is needed to produce change and fun learning. My experiences at the track and in the classroom at both CSUMB and elementary schools have proved invaluable and drove me to the idea of this project. I can say that I was able to answer my primary research question, “Using Themes Such as Motorsports as an Avenue to Incorporate Science, Technology, Engineering, and Math (STEM) Into Classrooms” convincingly. I can move ahead and have the knowledge gained from this capstone project with me. I learned that my passion for motorsports and teaching can be brought together as long as it is viable, which makes me excited for the future. I enjoyed this project because of that. This project also provided a spark for me. It showed me that I can get creative with what I teach and how I teach it. It showed me that I have a creative side. I hope future readers of this paper can realize that potentially combining their two passions to do something positive for others. My final words on this project echo what driver JR Hildebrand says on the subject in his Bloomberg article. He said, “Math and science are responsible for a lot of the most amazing stuff that happens in the world. The motorsports industry should be striving to make that a little more obvious.” (Chemi, 2014, Pg.1).

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Appendix 1

Motorsports Professional Interview Questions

1. What is your job in the motorsports industry?
2. How long have you been a member of the industry?
3. Do you use STEM (Science, Technology, Engineering, Math) in your everyday job? If so, how?
4. Do you feel motorsports can serve as a model to teach students about STEM?
5. Why is STEM important to Motorsports?
6. Why should motorsports be relevant to society?
7. Why is it important for students to know the basics of STEM even if they have no desire to join the motorsports industry?
8. Anything that you would like add?

Appendix 2

Motorsports Professional Interview - Thomas Merrill, November 5, 2015

1. What is your job in the motorsports industry?

My job is teaching competitive driving and racing skills to amateurs and young professionals in motorsports.

2. How long have you been a member of the industry?

I have been teaching professionally since 2007.

3. Do you use STEM (Science, Technology, Engineering, Math) in your everyday job? If so, how?

I sure do. I apply all of these in three ways: analysis, execution, and education. The cornerstone of driver coaching is post-session analysis. This is where we assess the driver's abilities and execution skills, identify the strengths and weaknesses, and plan objectives for the next session. It's important for us to be able to measure the performance of the driver using data acquisition, which involves lots of math and technology. The on-board computer measures everything on the car that moves and graphs the measures over time or distance traveled so that we can analyze the values and compare them to another driver or session. Primarily we measure time gained or lost, but we'll also measure brake pressure, throttle position, steering angles, engine RPM, line geometry, suspension travel, and of course, speed. We'll also use the data to monitor the performance of the engine and suspension to make sure everything is operating at optimal performance. Through execution, we use engineering and technology to improve the performance of the racecar. Based on driver feedback or data analysis, we can adjust the components on the car to optimize grip. Sometimes we can use the feedback and data to design and implement new components to add to the car to improve grip, horsepower, or reduce drag. Ultimately everything we are doing is for the benefit of driver education. In order to help the driver understand proper technique and car setup engineering, we have to look at the performance of the car scientifically. Simple things like how temperature affects horsepower and grip or how a particular driving line optimizes grip and lateral g-force all require a basic understanding of science.

4. Do you feel motorsports can serve as a model to teach students about STEM?

Motorsports is a perfect place to teach students about STEM. The sport is so multifaceted. Every job one can have in the industry requires an understanding of STEM. I would recommend it to any STEM student.

5. Why is STEM important to Motorsports?

STEM is important to motorsports for one simple reason: motorsports is about maximizing performance. The competitive nature of the environment requires an understanding of STEM, and those who have the best knowledge are the ones who are the most competitive. If you want to win, you have to be the best at STEM.

6. Why should motorsports be relevant to society?

Again, motorsports is multifaceted. From a triathlon-fit athlete to a collegiate scholar, there is a place for everyone in motorsports. It is well and truly a team sport, but unique to motorsports is the scientific element. It is not simply about maximizing an athlete's performance, but rather marrying that maximized athlete with a optimized machine. It takes a massively diverse and skilled group of people to make a successful racing team.

7. Why is it important for students to know the basics of STEM even if they have no desire to join the motorsports industry?

STEM is applicable outside of motorsports. A student who is well versed in STEM has many options for applying an succeeding with that knowledge.

8. Anything that you would like add?

If I didn't have a proficiency with STEM, I could not do my job.

Appendix 3

Motorsports Professional Interview– Nik Romano, November 11, 2015

1. What is your job in the motorsports industry? How long have you been a member?

I am a racing instructor and private coach, as well as a competitive driver in various series. I've been doing it since 1999.

2. Do you use STEM (Science, Technology, Engineering, Math) in your everyday job? If so, how?

Of course. Suspension systems are a geometry equation, internal combustion is chemistry, ECUs and tuning involve complex electronics and programming, etc, and a car on a racetrack is a physics experiment.

3. Do you feel one STEM subject is more important than the others?

I feel that in the racing industry, each STEM subject is best approached by an expert in the field. The car won't go without all of them, even including the mathematics/economics of funding the car. One person can be a generalist in every field and that is fine for an entry level team, but the more serious you want to get, the more important having a team of specialists becomes.

4. Do you feel motorsports can serve as a model to teach students about STEM?

Absolutely. It's like word problems on steroids. Not only is it a real-world application, it's a really really cool one that can be really fun to work through.

5. How do you use Math in your job?

Personally, only in very basic senses. I'll use percentages to describe certain aspects of vehicle dynamics and driving to my students, and I'll occasionally have to calculate gear ratios between transmissions and differentials, or pistons speeds, etc.

6. Why should motorsports be relevant to society?

It has all the same relevancy of any other sporting event, with the added bonus of helping to boost technological advancements in the automotive industry. Much of the tech we see in modern street cars was born on the racing circuit.

7. Why is it important for students to know the basics of STEM even if they have no desire to join the motorsports industry?

Having a basic understanding of the various branches of STEM can help you in many, many fields. I had no idea I was going to fall into motorsports in the way that I did, but with the understanding of STEM I already had (which, coincidentally, much of which I learned from being around racing my whole life), I was able to dive right into managing just about every aspect of the race team I was on.

8. Anything that you would like add?

Practical applications are always, ALWAYS more beneficial to becoming well versed in your field than just reading a book. Experience > sitting in a classroom.

Appendix 4

Motorsports Professional Interview-Mike Sweeney, November 17, 2015

1. What is your job in the motorsports industry? How long have you been a member?

I'm a temporarily washed up professional driver who runs a prep shop doing everything from fabrication to coaching. I've been working full time in motorsports for ten years, and first worked in a race shop 15 years ago now.

2. Do you use STEM (Science, Technology, Engineering, Math) in your everyday job? If so, how?

Obviously STEM comes into play every day in motorsports, especially in the shop. Every technique used in the construction and fabrication of a race car is a mix of these four key disciplines. It would be easier to find what we don't rely on STEM for in day to day operations, even the old fashioned techniques we use like welding are constantly being evolved with new equipment from the tech sector.

3. Do you feel one STEM subject is more important than the others?

For what we are aiming to achieve, I feel engineering is probably the most important. Basic engineering principles are what guide high quality production, and all the technology in the world will not result in a good race car if it is poorly screwed together. Science, Technology, and Math are the paths we use to make the components that make up the various separate systems, but the engineering behind the car as a whole is the key to success.

4. Do you feel motorsports can serve as a model to teach students about STEM?

I can't really think of a better model, and I think the success of the Formula SAE programs and the high-quality engineers they are producing is a pretty convincing argument for anyone who disagrees!

5. How do you use Math in your job?

Mostly by jabbing at a calculator while frowning at Machinery's Handbook. Really, the math part of this job is mostly 101 level stuff, and never really gets much past practical algebra and geometry for formulas, but it is frequent and critical! We are often using expensive machines to cut expensive materials that may have a few dozen billable hours into making them by the time you get to your last chance to destroy it with a bad machine input, so making sure your numbers are right is vital.

6. Why should motorsports be relevant to society?

I don't know that it should be intentionally, as it is necessarily a very high-quality endeavor, and any time you get a lot of smart people with a very high minimum-quality threshold you will find relevancy as a byproduct. I think a healthy sport with high participation is what we need to have relevancy, not rulesets that try to mandate certain

technologies. Race cars have a relatively narrow set of requirements, so I see a lot less potential for trickle down like we used to have due to the ultra-high level of tech on the current road car. Sure, the rearview mirror was invented at Indianapolis, but there's not much low-hanging fruit like that left! However, the personnel that make it in professional racing will always be relevant, because of how fast things move in racing and how critical everything is for a winning effort. The more people we have involved, the better.

7. Why is it important for students to know the basics of STEM even if they have no desire to join the motorsports industry?

It's important for them to know STEM basics because they're in school, presumably because they want to get a job that requires their higher education. If they aren't interested in that, they are wasting time and money in school and should just go do any number of the perfectly fine jobs that don't require higher education, and free up that seat for someone who is.

8. Anything that you would like add?

I would add that regardless of a student's vested interest in knowing the basics of STEM, our society as a whole needs more people educated in these fields. It feeds our industries, it drives innovation, and it means less people mixing bleach and ammonia while cleaning. These are all good things. Regardless of what these people do for a living, a society that understands the value of the scientific process, the benefit of making decisions based on data, and sees that the benefits of investing in STEM projects are manifold and unpredictable is a society that can adapt to whatever the future looks like.

Appendix 5

Teacher Interview Questions

- 1) Are there any flaws in the current Science/Math state curriculum? If so, what?

- 2) What is your opinion of STEM Education?

- 3) How do you think the integration of STEM benefits the students' learning?

- 4) Is STEM education currently a part of your or your schools curriculum?

- 5) Do you think a theme such as Motorsports can be easily used to teach STEM in classrooms?

- 6) In your opinion, can a theme such as motorsports be used in a common core curriculum instead of just a STEM based curriculum?

- 7) Do you feel that there are consequences for not including STEM into your curriculum? If yes, how so and what are they?

- 8) Anything else to add?

Appendix 6

Herman Principa

Teacher Interview Questions

- 1) Are there any flaws in the current Science/Math state curriculum? If so, what?
No actual curricular standards for CA. Nothing to support science - science teachers are going
- 2) What is your opinion of STEM Education?
It depends on how its done. As long as its a STEM school then students get all the curricular pieces needed, but pull-out programs aren't as good.
- 3) How do you think the integration of STEM benefits the students' learning?
They do get it all - not a fit-and-miss for all subjects. It gets students ready for what they will do in the real world.
- 4) Is STEM education currently a part of your or your schools curriculum?
A part of the school - it is total STEM.
- 5) Do you think a theme such as Motorsports can be easily used to teach STEM in classrooms?
Yes, as a project for a period of time, but not an entire year. It would have to be kid interest driven.
- 6) In your opinion, can a theme such as motorsports be used in a common core curriculum instead of just a STEM based curriculum?
Yes, it would have to be student interest driven, & coordinated with the teachers.
- 7) Do you feel that there are consequences for not including STEM into your curriculum? If yes, how so and what are they?
The only detriment is that an ordinary teacher doesn't have the time to get all subjects in, whereas the STEM program allows
- 8) Anything else to add?
that.

School - Herman Intermediate
the Adventure Program

- Adventure Stem on Facebook

Stem Art - new thing

Appendix 7

Teacher 1

Teacher Interview Questions

1) Are there any flaws in the current Science/Math state curriculum? If so, what?

NOT SURE - MAYBE SHOULD BE PUSHED

MORE ~~IN~~ OUR SCHOOLS, INSTEAD OF ENG/SOCIAL SCIENCE.

2) What is your opinion of STEM Education?

WHEN DONE WELL IT IS A HUGE ASSET TO STUDENT LEARNING & FUTURE SUCCESS.

3) How do you think the integration of STEM benefits the students' learning?

YES. MANY STUDENTS NEED THE PRACTICAL APPLICATION & "HANDS ON" EXPERIENCE STEM PROGRAMS BRING IN ORDER TO BE A MORE BALANCED & PRODUCTIVE FUTURE EMPLOYEE.

4) Is STEM education currently a part of your or your schools curriculum?

YES, I TEACH A LOT OF MATH & SCIENCE IN MY AVID CURRICULUM.

5) Do you think a theme such as Motorsports can be easily used to teach STEM in classrooms?

YES!!! SCIENCE, MATH & ENGINEERING ARE MASSIVELY IMPORTANT IN ALL LEVELS OF MOTORSPORTS.

6) In your opinion, can a theme such as motorsports be used in a common core curriculum instead of just a STEM based curriculum?

YES!

7) Do you feel that there are consequences for not including STEM into your curriculum? If yes, how so and what are they?

YES, IF THE UNITED STATES IS

8) Anything else to add?

GOING TO REMAIN A WORLD LEADER IN TECHNOLOGY, SCIENCE & MATH MUST REMAIN A PRIORITY IN OUR SCHOOLS CURRICULUM'S.

8. Anything ELSE TO ADD? - NO

Appendix 8

Teacher 2

Teacher Interview Questions

1) Are there any flaws in the current Science/Math state curriculum? If so, what?

A non-science oriented teacher would have great difficulty in making the connections between STEM topics and core academic subjects.

2) What is your opinion of STEM Education?

It is necessary for the future success of our country.

3) How do you think the integration of STEM benefits the students' learning?

It makes it more interesting and therefore more engaging for the students by more closely simulating real world applications of STEM topics.

4) Is STEM education currently a part of your or your schools curriculum?

Yes

5) Do you think a theme such as Motorsports can be easily used to teach STEM in classrooms?

Absolutely, ^{math,} physics, chemistry, psychology, biology, are all employed to ~~various~~ varying degree in ^{motorsports.}

6) In your opinion, can a theme such as motorsports be used in a common core curriculum instead of just a STEM based curriculum?

Sure

7) Do you feel that there are consequences for not including STEM into your curriculum? If yes, how so and what are they?

Yes, STEM topics are closely related to the natural world we live in and if

8) Anything else to add?

No

you don't understand the natural world, survival can become doubtful.

Appendix 9

Science
Tech
Engineering
Math

Teacher 3

Teacher Interview Questions

- 1) Are there any flaws in the current Science/Math state curriculum? If so, what?
Yes- Too difficult for some, testing is computerized - They need to do math pencil/paper.
- 2) What is your opinion of STEM Education?
I believe students would be motivated to learn because they would be interested in the topics.
- 3) How do you think the integration of STEM benefits the students' learning?
I think it adds motivation - a reason that they are learning each concept.
- 4) Is STEM education currently a part of your or your schools curriculum?
Not that I know of.
- 5) Do you think a theme such as Motorsports can be easily used to teach STEM in classrooms?
I'm not sure.
- 6) In your opinion, can a theme such as motorsports be used in a common core curriculum instead of just a STEM based curriculum?
Maybe as a class - not replacing an entire grade level of math or science.
- 7) Do you feel that there are consequences for not including STEM into your curriculum? If yes, how so and what are they?
There may be some students we could have motivated to enter the Math/
- 8) Anything else to add?
Science field if this was offered.

Appendix 10

Teacher 4

3pm
11/5/15

Teacher Interview Questions

1) Are there any flaws in the current Science/Math state curriculum? If so, what?

Currently new science standards are being introduced. The difficult part is training all the teachers to properly teach them in the classroom.

2) What is your opinion of STEM Education?

I feel there should be an emphasis on them starting in 3rd grade and pushed all the way through high school. More money is needed for hands on activities for students in class.

3) How do you think the integration of STEM benefits the students' learning?

My experience is most kids LOVE STEM type activities in the classroom if done right. This will spark a love of learning that should carryover to other subjects.

4) Is STEM education currently a part of your or your schools curriculum?

Yes, the teachers look for activities students can complete in class. Field trips are also used to spark a love for learning.

5) Do you think a theme such as Motorsports can be easily used to teach STEM in classrooms?

Not easily, but it can be done. It would need to be introduced as an endproduct and then shown in small steps to the class on what can be done in motorsports. If done correctly, the students will love the unit.

6) In your opinion, can a theme such as motorsports be used in a common core curriculum instead of just a STEM based curriculum?

Absolutely, the beauty of CC curriculum that anything can be taught when following the appropriate standards.

7) Do you feel that there are consequences for not including STEM into your curriculum? If yes, how so and what are they?

Yes, so many high paying careers are STEM related and the less students are shown the fun of STEM activities the less likely they are to pursue a career in those fields.

8) Anything else to add?

STEM is FUN and kids need to be shown this by their teachers.

Appendix 11

In-Class Presentation Slides



Rationale for Research

I chose this topic because I wanted to see to what level I could combine my two passions—teaching and motorsports.

I wanted to see if any programs or curriculums exist or if it was feasible to have one of my own in my own classroom.

Major Learning Outcomes

MLO 1, Foundations and Perspectives in the Major

MLO 8, Quantitative Literacy

MLO 10

MLO 11, Ethical Reflection and Social Responsibility.

Primary Questions

1) What are motorsports and what is STEM? What does research say about using a theme such as motorsports to motivate students into STEM field?

2) Are there any pros and cons for using a theme such as motor sports in the STEM subjects? Are there any advantages or disadvantages to incorporate it into STEM?

Secondary Questions

1. How can motorsports be integrated into science?
2. Can motorsports be applied to technology? If so, how?
3. How does the motorsports industry involve engineering?

4. To what extent does motorsports relates to Math?
5. Are there any resources for teachers to incorporate themes such as motor sports into the classroom by using STEM?

Literature Review

The mission of my literature review was to find out what motorsports are, what STEM is, and how the STEM Subjects and Motorsports intertwine.

I also set out to find if Motorsports can be brought into classrooms via STEM education.

Method and Procedures

In order to accomplish my mission, I consulted online sources, my own knowledge, various books, and personal interviews to find my information.

All interviews were with professionals in either the Motorsports or teaching professions. These people made the biggest difference in the result of my findings.

What are Motorsports?

Motorsports are "a sport involving the racing of motor vehicles, especially cars and motorcycles."

Otherwise known as car or motorcycle racing.

Actively practiced worldwide.

Nascar and Formula 1 are the two most popular forms of motorsports.



Why are Motorsports Important?



Motorsports provide testing grounds for furthering automobile technology and safety.

Motorsports provide tens of thousands of jobs worldwide as well as providing economic boosts to regions where tracks are located in.

Business growth

A good clean sport for youth to be involved in because of the many dimensions involved.

What is STEM Education?

STEM Education is an acronym that stands for Science, Technology, Engineering, and Math.

STEM Education aims to educate and prepare students of all ages for modern industry where Engineering and Technology is heavily used. If the United States wants growth and innovation, it will come through those industries that heavily involved Engineering and Technology.

STEM Education is growing throughout the country because of the demand.

What is STEM Education?

"STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy."

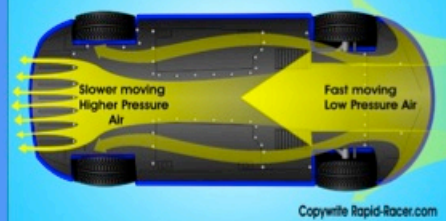
STEM is meant to better prepare students of all ages to excel in math and science. If they can excel in math and science, they can take those skills and integrate them in technology and engineering.

Motorsports and Science

Motorsports are a science experiment in action.

Aerodynamics, Physics, Chemistry, and Psychology are just a few of the scientific subjects used heavily in motorsports.

Car Underbody Aerodynamics



Motorsports and Technology

Technology is used to maximize performance in Motorsports.

Data Acquisition, simulation, and manufacturing are used to produce the best drivers and best cars.



Motorsports and Engineering



Engineering is what makes the vehicles perform at a high level. Between designing the cars and making them achieve the levels they were built for, engineering is very important.

Engineers are often the smartest people in the industry because they are able to use their math and science skills to maximize the speed of the car.

Motorsports and Math

Math is used in motorsports to solve problems. Some are simple, like calculating tire pressure or measuring ride height, but some are complicated, such as designing engine parts or measuring aerodynamic effects.

Some engineers are mathematicians who specializes in motorsports concepts.

<http://consultkeithyoung.com/content/applied-math-example-definite-integral-f1-race-car-telemetry-data-braking>

Minorities in Motorsports

Minorities are found all over Motorsports. Because of its worldwide appeal, every race has a presence in Motorsports. For example, Lewis Hamilton, 3 time and current F1 champ, is black.

Women have a strong presence in motorsports too. From driver Danica Patrick to engineer Leena Gade, there is a place for everyone in Motorsports.



Programs and Resources

Mazda and Chevron are two leading examples of companies who invest in STEM Education.

Mazda's RACE program shows how Motorsports and STEM combine to produce their product, both on the racetrack and on the street. It chooses one school near the racetrack where they are competing at and give a presentation.

Chevron needs employees who specialize in the STEM fields, so they support teachers and students who need the help to do so.

In 2014, Chevron invested nearly \$95 million in education partnerships and programs worldwide.

In the United States, our total investment in education has been more than \$140 million since 2010. This work has enhanced the educational experiences of more than 700,000 students.

Pros and Cons

Pros

- Fun, multifaceted subject
- Serves well for visual learners
- Inspires students who don't see purpose
- Makes learning fun
- Applicable outside of Motorsports

Cons

- Not every student will be drawn to Motorsports or even STEM
- May be costly
- Not every teacher will be capable of teaching a curriculum based on motorsports

Results and Discussion

As a result of my research, I found that a Motorsports themed curriculum isn't likely to succeed. The cons are big issues while the pros, while great, don't serve all the students.

Motorsports can be a theme of a unit of lesson, but not a whole curriculum.

I still plan to use Motorsports in some capacity in my future classroom.

These findings opened up the possibilities of unique themes for lessons and even curriculums.

This project caused me to find an interest in creating such lessons and opened my eyes further to how much fun teaching will be.

Problems and Limitations

I had little problems with my project. My greatest issue was finding information that was specific to my project. I am in uncharted territory.

The limitation was finding information that directly related to Motorsports and Elementary school curriculum. There are no studies or reports that say that my idea could work or could fail. Because of this, I had to ask the teachers and administrators what they thought and came up with my conclusion based on what they said.

Conclusion

In conclusion, motorsports can be used as a theme or subject of a lesson, but not a curriculum. It is not feasible for every student to be interested in motorsports and to have to educate other teachers in a subject such as motorsports. Motorsports and STEM are very closely related, but are better off being pursued by students directly interested in motorsports and STEM specifically.

Appendix 12

Potential Lesson Plan

Grade: K-2

Subject: Science/Physics

Goal: Teach students the beginning phases of pushing and pulling forces.

Materials: Diagrams supplied by teacher, videos, and boxes that vary in size that are colored and shaped to look like a racecar.

Step 1: Explain to the students what a “pushing force” accomplishes, then what a “pulling force” accomplishes.

Step 2: Have the students experiment these forces on the racecar box.

Step 3: Explain what happens when too much force is applied. Demonstrate by crushing the box in front of the crash. Have students reciprocate.

Step 4: Explain that a big force is required to crush the big box while a small force is required to crush the small box.

Step 5: Small quiz on forces