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Abstract:

During the past several decades we have seen an increase in the demand for individuals trained in STEM (science, technology, engineering and mathematics) disciplines (Rothwell, 2013). While this is this case, according to the Bureau of Labor, the United States will see a shortage of STEM workers over the next decade, with the demand for highly trained STEM workers exceeding the minimal supply (Rothwell, 2013). In a study of bachelor and associate students in the academic year of 2003 and 2004, only 28% of bachelor students and 20% of associate students entered STEM fields (Chen & Soldner, 2013). This study took place from 2003 to 2009, and it was reported that 48% of these bachelor students and 69% of the associate students either switched to a non-STEM major, or dropped out of school. One major aspect that was found to impact attrition rates in STEM majors is precollege experiences and preparation. This issue can be directly related to the education system and its lack in preparing today's students to fill the overwhelming amount of positions (Educator's Voice). This is evidenced by low test performance of U.S. students as compared to those from other countries on several STEM assessment tests, which is causing the U.S. to lag behind other developed countries in the global economy. It is well established that in order to retain students in STEM majors, interest in these fields needs to be cultivated at a young age (Dejarnette, 2016). It was reported that 94% of eighth grade students chose their courses in order to prepare for a future career. If these students do not have interest or see potential in STEM fields and careers at this age, it is unlikely that these students will remain in the field (UMASS Donahue Institute, 2011). Unfortunately,

however, it is very common for students to go through school not knowing the purpose of much of their learning. Specifically in middle school science classrooms, students often perform experiments where they are given step-by-step protocols where the outcome is known. However, this does not represent how science really works. The purpose of this project is to conduct a thorough literature review of current practices in STEM education in the middle school classroom. Using this information, a module appropriate for middle school science classrooms will be developed and aligned to 2016 Massachusetts Science and Technology/Engineering Curriculum Frameworks standards. The activities in the module will be focused on practicing the real processes of science, and will also be inquiry-driven, allowing students to explore and discover for themselves. Ultimately this will allow students to see purpose in their work, become aware of the exciting world of science, become familiar with the process of science and take interest in the field. As a result, it is expected that more students will pursue STEM careers after being exposed to such modules, which will help the U.S. to improve its position in the global economy.

Introduction:

One of the most important purposes of schooling and education is to prepare students for their future careers. The acronym STEM has become popular in both the education world as well as the workforce (Breiner et al., 2012). This acronym stands for science, technology, engineering and mathematics. Due to the second wave of globalization, economic success no longer is dependent upon a nation's natural resources and economic system, but instead on human capital. It is a country's population that determines its success in the present century (Teitelbaum, 2014). With the more high-tech global economy, there have been increased demands for educated professionals in the fields of science, technology, engineering and mathematics (Rothwell, 2013). According to Rothwell (2013), as of 2011, 26 million U.S. jobs require a high level of knowledge in any one of the STEM fields. However, the United States is lagging behind other developed countries when it comes to the number of workers pursuing careers in such fields (Dejarnette, 2016). According to the National Math & Science Initiative, the U.S. may be lacking nearly three million workers with the skills needed for new job openings by 2018. This is a result of a lack in STEM education in the early years of schooling, such as middle school, and according to the 2011 Trends in International Mathematics and Science Study (TIMSS),, U.S. eighth graders scored significantly lower than eight other countries in science literacy (National Science Foundation, 2011). Many middle school science classrooms focus on "cookbook" or kitchen labs that involve following specific steps to reach an expected outcome, instead of having students engage in inquiry-based learning. It is argued that schools need to move away from teaching strictly content, and focus on teaching the processes of science to students instead in order to prepare them for the real world of science beyond the school doors (Dejarnette, 2016). One example of a teaching and learning model to help incorporate inquiry into classroom lessons is the 5E instructional method. The 5E Learning Cycle is an instructional approach that draws attention away from meaningless academic experiences, and instead focuses on building a deeper understanding of topics so that students are able to apply their learning in new and different situations as they are presented to them (Llewellyn, 2014). This learning cycle consists of five steps: Engagement, Exploration, Explanation, Extension, and Evaluation. The engagement stage is crucial when beginning a unit in order to capture student interest and spark their curiosity. This stage is also helpful in allowing teachers to assess prior knowledge students have on the topic at hand. The exploration stage is entirely student-led and is a time for students to develop questions to be tested. This is a time for students to investigate through hands-on activities. The explanation stage shifts to a teacher-led environment to explain underlying concepts and bring all students onto the same playing field. During the extension stage, concepts are applied to real world scenarios in order for students to make meaningful connections to their work and find purpose in what they are doing in the classroom. Finally, the evaluation stage is where the unit comes to a clear closing and concepts are clarified and connected so they make sense (Llewellyn, 2014). Although schools have taken several steps to incorporate an inquiry-based learning style into curricula, it is rarely practiced in the classroom (Dejarnette, 2016). Without this exploration and discovery, students often lose interest in the subject as they feel the questions have already been answered. Often times this happens early in their educational careers. Students then carry this attitude and outlook with them as they further their education. As a result, few students are pursuing STEM careers upon graduation, causing the U.S. to fall behind other competing countries. Even though there have been strides toward improving these numbers in the U.S., room for improvement in the curriculum remains in order to help students to find relevance and importance in STEM education and better prepare them for careers in these fields. This thesis proposes that engaging students in real world tasks through inquiry-based modules adhering to the 5E instructional method will help to spark student interest in the STEM fields and make them aware of the possibilities that their futures hold.

Literature Review:

Current Middle School Science Practices in the U.S.

As outlined above, the U.S. is facing a major issue, which is directly affecting its position in the global economy. The U.S. is falling behind other countries economically due to the lack of people filling STEM career positions in the high tech society (Dejarnette, 2016). This can be directly connected to the practices in current U.S. middle schools, as they are not preparing future generations for these careers (Educator's Voice). Although young students are born with a natural curiosity about their surroundings, educational systems today have shifted their focus toward standardization, stripping this inquisitiveness from students (Educator's Voice). Even though there have been numerous attempts to reform education in order to solve this issue, these reforms toward engagement and inquiry have been greatly ignored in U.S. science classrooms (The National Academies Press, 2015). The National Academies Press (2015) utilized four surveys to develop a better understanding of current science practices used in the classroom by U.S. science teachers today. The surveys focused both on instructional practices as well as teacher's beliefs and views about the effectiveness of these practices. The National Survey of Science and Mathematics Education reveals a gap in expectations and reality. Only 17% of teachers report that they require students to provide evidence for their claims. Many job positions that will be available to 21st century learners will require them to think creatively and critically, problem solve, and be able to defend themselves and the positions they take on certain issues. Being able to provide supporting evidence and make a valid argument is crucial to many careers, and therefore, it is important that students are familiarized with this practice early in life so they can master it prior to entering the workforce.

Educational researchers, Weiss et al., performed a study in which they ranked the instructional quality of lessons on a scale from 1 to 5. This study included 93 schools in the United States and rankings depended on whether the lessons helped students to develop a conceptual understanding of topics and whether students were engaged in the processes of mathematics and science. An example of an exemplary science lesson, a lesson ranked 5 by Weiss and colleagues was a high school biology lesson. In this lesson students were asked to make predictions/hypotheses about what the outcomes of an experiment would be. They then discussed their hypotheses and approaches as a class while discussing their findings as well. After communicating their results and ideas, students worked together to create a story that connected their new knowledge to organisms found in their local area. Out of all elementary, middle and high school lessons observed, they ranked 59% of the lessons as low quality (1 or 2 using their scale). Based on their studies, these researchers also concluded that middle school lessons were weaker than elementary and high school science lessons. Of the middle school lessons, 78% were ranked as low quality. These lessons lacked the time and structure to allow students to make sense of their learning. In an example of an ineffective science lesson according to Weiss et al. students were directed to fill in a worksheet and were then guided to take notes, both of which were heavily focused on factual information provided by their textbook. Students were moved along in a timely manner and were not allowed sufficient time to question or ponder the new information. Also, the students were expected to accept the facts, and connections to prior knowledge and real-world scenarios were absent from these lessons (National Academies Press, 2015).

Since the U.S. is falling behind other countries in academic achievement in STEM fields and on a larger scale in the global economy, it is evident that these other countries are using more effective teaching strategies that help to better prepare young students for future careers where they will be needed (National Academies Press, 2015). U.S. students appear to obtain a more advanced science education due to the fact that more challenging topics are introduced to students earlier in their educational careers (Butrymowicz, 2011). However, these students tend to memorize facts, rather than develop a true understanding of the concepts at hand (Butrymowicz, 2011). Videos of eighth grade classrooms in five lower achieving countries (unnamed, but including the U.S.) have been analyzed from the Trends in International Mathematics and Science Study (TIMSS). These videos reveal that the five countries observed focus heavily on observation when it comes to laboratory activities. High achieving countries such as the Czech Republic, Netherlands, Japan and Australia, on the other hand, were characterized as having discussions to conclude and make sense of the results obtained from their controlled experiments. It is hypothesized that the lack of competency in science in students in the United States results from how the information is taught in the young grades. The 2007 TIMSS results for fourth grade science show that the U.S. ranked significantly below Singapore, Taiwan, Hong Kong and Japan. The TIMSS eighth grade results show that the U.S. ranked below 9 countries in their scientific literacy, including England, Hungary and the Czech Republic. It is evident that a downward trend begins to form as early as the fourth grade. Results from the 2009 Program for International Student Assessment (PISA) report that 15 year-old U.S. students ranked below 15 year-olds in 20 other countries in their science literacy (Butrymowicz, 2011). PISA aims to measure literacy in science, mathematics, or reading, and does not focus on particular curriculum frameworks (National Center for Education Statistics). This further shows that this downward trend continues past elementary and middle schools, and impacts students at both the high school and college levels. Butrymowicz (2011) argues that as these students move through their education, the knowledge they gain is superficial due to the lack of having a solid foundation to build upon. This phenomena has been coined as “a mile wide, and an inch deep” science education, which is characteristic of the U.S. By utilizing this approach, numerous topics are covered, but students do not get an in-depth understanding of the topics before moving on. Other countries, on the other hand, are covering fewer topics in more depth, and as a result, their students are performing higher in the classroom, and on standardized tests used to evaluate knowledge in the STEM fields (Butrymowicz, 2011). When it comes time for U.S. students to attend college and follow a path of interest to them, it is not surprising then that only a very small amount choose to pursue a future in a STEM field. In 2006, only 29.3% of males and 15.1% of females continued their education in a STEM field (Butrymowicz, 2011).

The impacts of the “mile wide, inch deep” approach to education in the U.S. are well documented. Therefore, one cannot understate the importance of being able to differentiate between knowledge and understanding, which is something that U.S. teachers struggle with consistently (Tanner & Allen, 2005). This is evidenced by the fact that research has shown that U.S. teachers use student assessments that measure knowledge of a subject rather than understanding of the subject (Tanner & Allen, 2005). Knowledge is considered to be the knowing of facts, and is related to a superficial way of learning. On the other hand, understanding is related to conceptual thinking and application of knowledge. According to Tanner & Allen (2005), even if a student has demonstrated mastery of a concept in class, understanding has not been achieved unless the circumstance can be changed and the student is able to apply this knowledge to a new and unfamiliar situation. Literature suggests that students need to be able to connect new material with prior knowledge and their own worldviews in order to develop this true understanding of new material (Tanner & Allen, 2005). It is recommended that teachers adopt a teaching style that allows for inquiry-based learning in order to engage students and help them to transform their knowledge into understanding. Although this call for reform has pointed U.S. teachers in the right direction toward inquiry, which has been an idea persisting from the 1930s, it is still not common to see this type of learning in U.S. schools decades later.

Researchers, Weiss et al. (2003), have performed a study focused on the content being covered as well as the pedagogies seen in sixth to eighth grade science classrooms in selected U.S. schools. They found that a majority of the science lessons (84%) focused on only one topic, and nearly three quarters of the lessons focused on either life science or physical science. Also, only 9% of the lessons involved science as inquiry and 0% of the lessons revolved around science and technology, despite the overwhelming evidence indicating that these are necessary for student success and retention in the fields. These researchers also looked at the likely impact that science instruction would have on students. They concluded that 31% of lessons are likely to have a negative impact on students' capability of seeing the importance of investigation to science, while only 25% of the lessons are expected to have a positive impact on this same aspect. Observers in this study ranked the lessons on a scale from 1 to 5. A ranking of 1 meant that the instruction was seen as ineffective (passive learning), and a ranking of 5 meant the instruction was thought to be exemplary. High quality lessons were thought to enhance student understanding of concepts and engage them in the process of science. Low quality lessons, on the other hand, did not engage students in the learning process. An example of a high quality lesson thought to have a positive impact would be a class discussion of interpreting data and identifying trends in class data. In contrast, an example of a low quality lesson thought to have a negative impact would be a science class where students follow an experimental procedure, but do not know why they are performing the steps. It can be seen that the negative impacts outweigh the positive impacts, which is a major underlying cause of the U.S. following behind other countries. It is evident that U.S. schools are not approaching middle school science with effective methodology, but it seems as though the answer is right in front of them, inquiry. The question then becomes, why aren't U.S. schools adopting the method of inquiry into their classroom routines?

Hindrance to Inquiry-Based Instruction

Although inquiry has been a suggested resolution to improve the issues characterizing U.S. middle school science education, there are still several factors that prevent teachers from adopting this teaching style. According to Trautmann et al. (2004) there are several myths held and believed by teachers that explain their reasoning for not implementing inquiry into their classrooms. The first myth is that teachers have the majority of the knowledge, which must be transferred to the students. The second myth is that the amount of content being covered is of higher importance than the deeper understanding of these concepts. The third myth is that teachers need to maintain the curriculum in order to help students to perform well on examinations. Finally, the fourth myth is that teachers need to be in control of the learning in the classroom to ensure efficiency.

According to Wilcox et al. (2015), another myth preventing inquiry being adopted in science classrooms is the belief that inquiry means a complete hands-off approach by teachers, leaving students to discover science concepts all on their own, which is not consistent with how science has occurred throughout history. These authors argue that teachers play an important role in teaching science through inquiry. For example, teachers are responsible for asking questions that spark student interest and creative thoughts, requiring students to recall and make use of prior knowledge, making students responsible for communicating their work effectively, and having students work together to collaborate and make important decisions together. These authors also explain that when using an inquiry based pedagogical approach, the teacher must provide more guidance at the beginning when familiarizing students with this approach and slowly give students more responsibilities. However, teachers should provide some level of guidance at all times.

An investigation focused on preservice teachers found that even though preservice teachers received training for inquiry-based teaching, they often did not apply this style to their teaching because they were not taught this way during their schooling (Binns, 2013). Another barrier to teachers including inquiry based teaching practices in their classrooms is how new teachers are being trained. During student teaching, new teachers are learning from older teachers. These new teachers are aware of the recommendations to increase and incorporate inquiry into their classrooms due to their enrollment in methods courses, but the observations of their mentor teachers do not emphasize this teaching style (Binns, 2013).

It has also been reported that teachers are unsure of how they will measure the progress students have made or the success of their students. Specifically they are unfamiliar with the ways to assess their students when using such a different style of teaching. Also, teachers have long been trained to teach to the test and to strictly follow standards to do so. Including inquiry then means changing everything that is familiar and comfortable for teachers (Binns, 2013). It takes courage and perseverance to overcome these challenges and introduce inquiry to the classroom. There is evidence that inquiry-based teaching has been found to be successful when implemented, and this is an important leap that the U.S. needs to take in order to save the country as a whole.

Benefits of Inquiry-Based Instruction

Maxwell et al. (2015) differentiates between inquiry-based learning and traditional learning. Inquiry-based learning gives power to students by allowing them to figure out the driving questions, devise plans to investigate these questions, and finally share their findings. Textbooks, worksheets and demonstrations by the teacher, on the other hand, characterize traditional learning. It is suggested that inquiry-based learning allows students to develop problem-solving skills and relate new knowledge to prior knowledge to make sense of concepts. Traditional learning revolves around memorizing facts, which does not allow for students to grow and understand.

Other countries, such as Turkey and Taiwan, have proven more effective in creating success in the science classroom (National Science Foundation, 2011). In a recent review, scientists performed a meta-analysis where they analyzed nineteen studies that focused on academic achievement, science process skills, and attitudes toward science in both inquiry-based and traditional classrooms in Turkey (Aktamis et al., 2016). When analyzing student achievement, scientists found that there was an effect size of 1.029, which is larger than 0.80, therefore it is considered a large effect size. From this, the scientists concluded that student achievement under IBL is significantly higher than student achievement in traditional classrooms. When these scientists analyzed the impact of IBL on student process skills they found an effect size of 0.742, which is considered to be a medium effect size. From there the scientists performed a z test and concluded that this was a significant difference, and that students exposed to IBL were better able to process science when compared to students instructed via traditional methods. Finally, when analyzing students' attitudes toward science when comparing the two groups, scientists found there to be an effect size of 0.558, which was statistically significant according to the z test performed. Based on the statistical analyses performed after data was gathered from various studies, researchers were able to conclude that all three aspects studied were improved when students were taught using an inquiry-based teaching style.

Results of implementing inquiry-based instruction have proven the effectiveness of this teaching style. In a recent investigation, two fifth grade science classrooms in a Georgia school were the focus of a study looking at the impacts of inquiry-based learning (Maxwell et al., 2015). The researchers of this study used pretest/posttest, surveys and checklists to make conclusions of effectiveness on student achievement, attitudes and engagement. When comparing the results from pretests and posttests, the Physical Science Knowledge Assessment, researchers found that students in inquiry classrooms made improvements from pre to post test, but the gains were not found to be significant. The achievement of the students exposed to IBL rose from 74.95 to 78.82. Also, when reviewing the checklist to examine student engagement, scientists found that students in inquiry-based classrooms were 16% more engaged and focused on topics than in the traditional classrooms, but this was not considered to be significant. While IBL students were engaged 79% of the time, students in the traditional classroom setting were engaged for only 63% of the lessons. Although both of these differences were not found to be significant, the authors suggest that this could be a result of small sample sizes and differences between the demographics of the two groups chosen for this study

Another study performed on students at a school in Taiwan tested the impact of inquiry based learning by studying both control and experimental chemistry courses (Chang et al., 2014) In the experimental group, students are exposed to a curriculum that allows for visualizations of reactions via technology, and encourages inquiry by having students apply knowledge and understanding of visualizations to create their own models and critique them. Students were given pretests and posttests to measure the impact. An ANCOVA test demonstrated the significance of the curriculum change. While the control group had only a mean score of 9.6 points on the post-test, the experimental group had a mean score of 29.43. The researchers of this study also looked at how this change in curriculum impacted students' ability to visualize reactions. They found that 13 out of the 28 students in the experimental group improved their visualizations. On the other hand, in the control group, even though a majority of the students who did not provide a response on the pre-test provided an appropriate response on the post-test, these students did not demonstrate a strong sense of what these reactions look like. This study further demonstrates the success of inquiry-based instruction on both student achievement and understanding.

A study was performed in 2006-2007 on sixth grade students in Turkey during a unit on the circulatory system. The purpose of this study was to determine whether the 5E instructional method is more effective than traditional methods of teaching. In order to measure the effectiveness of this instructional technique, authors compared pre and post-test results. It was found that post-test scores for the group of students taught under the 5E instructional model were higher than those for the group of students exposed to traditional teaching methods. There was a significant difference between the post-test grades of the two groups. With the 5E model focusing on inquiry-driven learning, this study further supports the benefits of inquiry-based instruction on students' academic success (Cardak, 2008).

Ultimately, the literature shows that the U.S. is falling behind in the global economy, and a major cause of this issue stems from the U.S. education system and its lack of preparing these students to fulfill the growing number of available STEM careers. The U.S. has performed lower than other developed countries on several international exams, and this has been found to be a result of how students are instructed at young ages. Other countries that have implemented inquiry-based instruction and the 5E instructional method in classroom lessons have achieved success. Therefore, a module for middle school students in the U.S. that incorporates inquiry and the 5E instructional method has been introduced to increase awareness and preparation for the real world of science, and ultimately improve the U.S. position in the global economy.

Methodology:

Five different seventh-grade science classes, 125 students total, participated in this two-week long guided-inquiry module. Table 1 summarizes the activities for each of the lessons that these students took part in. Throughout the module, students worked independently, with partners, and in small groups. Although this module was designed to be student-centered, the teacher still had an important role each day. The teacher helped students to recall prior knowledge and build upon this prior knowledge in order to then apply their knowledge in a real world-based design project. The teacher created interactive presentations to relay important information, which required students to come up with the information and then checked in to make sure students had the correct information. Finally, the teacher helped provide clear instructions and expectations and helped guide class conversations and lead students in the right direction.

Day 1:

During the first meeting, students were introduced to the new unit of study, transportation systems. Students took a pre-test that consisted of 15 questions. Of the 15 questions, eleven were multiple-choice, one was a diagram and the last four were ranking questions. The pre-test covered the content as well as student attitudes toward science as it pertains to their lives. After students completed the pre-test, they were shown a quick video displaying transportation systems from 8,000 B.C. to 2015. During the video, students were given a notecard to write down three similarities, differences or observations about the vehicles they saw in the video. These notecards then, due to a shortened period, were collected as a ticket to leave to be continued with during the next class period.

Day 2:

During the second class meeting, students were given their notecards back and were organized into groups of three. Students were instructed to share their ideas from the video and their notecards and organize their ideas neatly on the larger piece of paper. Students were also asked to write down what they believe the purpose of transportation is on their large piece of paper. Students were given 5 minutes to accomplish this brainstorming and organization of ideas, and then performed a gallery walk to observe their other classmates' ideas. The teacher then brought the class back as a whole to discuss their thoughts and ideas briefly. Students were then directed to retrieve their Chromebooks and the teacher passed out a note sheet. The teacher engaged students in an interactive presentation using Pear Deck. The presentation covered the purpose of transportation, the modes of transportation, engineering careers related to transportation, etc. Students were asked to respond to questions on their computers by typing in short answers, moving a dot to an agree/disagree or thumbs up/thumbs down visual, sketching images with the mouse pad, etc. Students were also instructed to record important information on their guided note sheet.

Day 3:

At the beginning of the third class meeting, students were reminded of the first two classes where they began exploring transportation and learning about the engineering careers involved with the different modes of transportation. They were asked to take out their note sheet from the previous class and choose to take the role of either an automotive, naval or aerospace engineer. Students were given a blank sheet of computer paper and told to write their name and career choice at the top. They were then directed to design a unique vehicle as a person with their selected career would. They had to draw their design and label all parts. Students were given 5 minutes to complete this task and then their designs were collected. The teacher then informed students that they had just created a transportation system, but then posed the question "What exactly is a system?" Students were then shown a picture of a bike, and asked if the bike is a system. Due to discrepancies amongst students about the answer to this question, the students were set off with a partner to label the different parts (at least four) of the bike and their function. The teacher then gathered the class as a whole to ask what the purpose of a bike is, and then asked students to share what they came up with for the parts. The teacher then helped lead students into creating the definition for a system. Students were then asked to brainstorm other systems, and the teacher then had them focus on their school as a system, something they are all familiar with. Students were given a worksheet and asked to work with their partner to brainstorm the different parts of a school. As a whole group, the teacher asked questions about what would happen if something went wrong with one of these parts to help students realize that all the parts are connected. The teacher then introduced the term subsystem and asked students to define it. The teacher informed students that they just brainstormed subsystems in the last activity. The teacher then led students to create the definition for subsystem and directed them to think about their school as a subsystem of the larger education system. They were then given a sheet to brainstorm other subsystems the education system. To wrap this activity up, the teacher informed students that like all systems, transportation systems have subsystems as well.

Day 4:

Students were introduced to the idea that there are six subsystems of transportation systems. They were given a note sheet, and the teacher first reviewed the definitions for systems and subsystems that students were able to create in the previous class. The teacher also introduced the names of the six subsystems of transportation systems. This information was recorded on students' note sheets. Students were then divided into small groups to work through a set of stations for each of the subsystems. At each station, there was a print out of a PowerPoint slide. The name of the subsystem and examples of different parts/devices that belong to the subsystem were found on the slide printouts. Student note sheets had spots for students to fill this information in. Their sheets also had two boxes, one that ask for their definition and one that asked for the correct definition. In their stations, students were asked to fill out the "Your definition" box. After students had time to make it through each of the stations, the teacher gathered the class as a whole again to quickly present a PowerPoint and presented students with the correct definitions for each of the subsystems. The teacher then returned the students' designs from the previous class and they were asked to write one explaining each of the six subsystems in their designs, a total of six sentences. If the subsystem was not present in their design, students were told to write a sentence explaining how they could redesign to include this subsystem. Students finished these explanations for homework.

Day 5:

Students were given a worksheet to answer questions about their classmates' designs. The students were asked to pass their designs around the class to other students and then told to stop randomly. They were asked to answer a series of questions for this design regarding the subsystems and whether it would function or not. Students analyzed and evaluated two classmates' designs. They were then partnered with a classmate and given the pieces of a puzzle. Students needed to organize the pieces of the puzzle into strips in the order of subsystem name, definition/ purpose, and example. There were a total of 18 pieces of the puzzle, 3 pieces for each of the six subsystems. Students were encouraged to complete this task carefully, yet in a time-efficient manner. Students who finished the entire puzzle correctly and quickest were rewarded.

The teacher then brought the class back together as a whole to review the correct puzzle order, and answered any questions students had. Students were then given key chains with the letters A-D on small cards. Students were asked to answer a series of questions (one at a time) in order to check their understanding of the transportation subsystems, the purpose of transportation, and transportation engineering careers. The teacher took note of students that had several misunderstandings in order to pull these students aside the following class to check in.

Day 6:

Students began class by completing a worksheet with the functions and examples of each of the transportation subsystems. The students were then provided with their project packets and introduced to their challenge and the real world transportation issues that they are going to attempt to resolve through their designs. The teacher walked through the different parts of the packet with the class as a whole. The teacher also reviewed what an RFP is and how they are used in the real world in many careers. Students were then assigned their groups for the project and were allowed to begin their packets. Students first picked a scenario that all group members were interested in and then began working in their packets. All project packets were collected at the end of class.

Day 7:

Student project papers packets were returned to students at the beginning of class. The teacher displayed four short video clips to students to provide a visual for each of the transportation issues. Students took brief notes/ observations in their packets for the video pertaining to the issue they chose to work with. Students then gathered in their groups again and continued to work on the team engineering design process for the remainder of class. Project packets were collected again at the end of class.

Day 8:

Students were given the class period to gather with their groups and completed the team engineering design.

Day 9:

Students were given back their project packets and the teacher handed out the individual proposal assignment with guidelines and a rubric. The teacher reviewed these papers and explained that the proposal is a response to the Request For Proposal (RFP) and explained how this is a popular task in businesses in the real world. Students were shown how to access the Web Paint program to be used for the proposal project. Students then began creating their transportation designs on the computers for their individual proposals for the remainder of class.

Day 10:

Students retrieved and signed into Chromebooks. They were shown how to login and open a blank poster on the Canva site. They then competed their transportation designs and uploaded their designs to their proposal posters by the end of class.

Day 11:

Students took their Transportation Systems Unit Test. Student project papers were returned to them upon completion and students worked on their online proposals for the remainder of class.

Day 12:

Students were given a checklist for their Canva proposal and shown examples of Canva posters to demonstrate the capabilities of the program. Students were instructed to refer to their project papers, the specific checklist and figure the program out on their own.

Day 13:

Students were given the class period to finish their proposals. Students were given scrap sheets of paper as a ticket to leave this day. After students were directed to submit their proposals with 10 minutes left in class, the students were asked to find a partner to share their proposal with. They had to write down one aspect of their partner's proposal that they enjoyed. After allowing the partners to each share their proposal briefly, they had to find another partner to share with and perform the same task. Finally, students found a third partner, performed the same task, and logged out of their computers.

Data/Results:

All students in study increased their score from pre to pos- test.

Pre and post-test averages were calculated and compared using a single-tailed t-test. The average for the pre test was a 56.5% (n=122) and that for the post test was an 89.2% (n=120) (p value <0.001). Pre and post-test scores were compared for each student, and a percent increase for each student was calculated. A negative percent increase would result from a decrease in score from pre to post-test. There were no negative percent increases in this study, meaning that all students in the study performed the same or improved their scores from pre to post-test. Table 1 shows a complete breakdown of the number of students for every 10% increase range. More broadly, there were 49 students that fell in the percent increase range of 0-50%. There were 48 students that fell in the percent increase range of 51-100%. There were 7 students that scored in the 101-150% increase range. Nine students had a percent increase between 151-200%. Finally, there were 7 students who had a percent increase over 200%.

Table 1. Amount of Students that Experienced a Percent Increase in Each of the 10% Increment Ranges

Percent Increase Range	Number of Students
0-10%	4
11-20%	14
21-30%	10
31-40%	12
41-50%	9
51-60%	15
61-70%	10
71-80%	16
81-90%	4
91-100%	3
101-110%	0
111-120%	2
121-130%	2
131-140%	3
141-150%	0
151-160%	2
161-170%	0
171-180%	6
181-190%	0
191-200%	1
200+%	7

Many student views and attitudes toward science changed after being exposed to this guided-inquiry based unit.

On both the pre and post-test, students were given four questions to be answered using a Likert Scale. These four questions were actually statements about science and science in the students' lives, and the students had to pick a number 1 to 5 on this scale depending whether they strongly disagreed (1), disagreed (2), neither agreed or disagreed (3), agreed (4) or strongly agreed (5). Each student response to these four questions on the pre-test was compared to their post test response to see how many students' attitudes and views were changed as a result of this unit and specifically how many students' changed their views to a more positive one.

Question 1:

The first question stated, "I plan to use science in my future career". After the guided inquiry module, 53 of the 118 students had changed their response from before the unit. Of these 53 students, 40 had *increased* their rating on the Likert Scale. Twenty-six students increased their rating by 1, eleven students increased by 2, two students increased by 3 and one student increased by 4. The other 13 students out of the 53 that changed their responses had *decreased* their rating on the Likert Scale. Eleven students decreased by 1 and two students decreased by 2.

Question 2:

The second question stated, "Science plays a role in my everyday life". After the guided inquiry module, 57 of the 118 students changed their responses. Of the 57 students, 46 had *increased* their rating on the Likert Scale. Thirty students had increased their rating by 1, eleven students increased by 2, and five students increased by 3. The other 11 students of the 57 who changed their response, *decreased* their rating. Ten students decreased their rating by 1, and one student decreased their rating by 2.

Question 3:

The third question stated, “There are many career options in science”. After the guided inquiry module, 50 of the 118 students had changed their responses. Of these 50 students, 33 made positive changes to their response. Twenty-four students increased their rating by 1, four students increased by 2, three students increased by 3 and two students increased by 4. The other 17 students had changed their response to a more negative one. Sixteen students decreased by 1 and one student decreased by 2 on the Likert Scale.

Question 4:

The fourth question stated, “Science is a process”. After the guided inquiry module, 57 students changed their responses. Of these 57 students, 34 *increased* their ratings on the Likert Scale. Twenty-three students increased their rating by 1, seven students increased their rating by 2, three students increased their rating by 3 and 1 student increased by 4. The 23 other students that changed their response had decreased their rating. Sixteen students decreased by 1, six students decreased by 2 and one student decreased by 3 on the Likert Scale.

Students agreed or strongly agreed that this unit made them more interested in pursuing a science/engineering career, connected to the real world and allowed them to think critically.

Statement 1:

Students were also given three extra questions at the end of the unit to be answered using the same Likert Scale. The first statement read, “After the transportation systems unit, I am more interested in pursuing a career in science/engineering”. As displayed in **Figure 1** (below), 9.5% of the students strongly disagreed (1 on Likert Scale), 15.5% disagreed (2 on Likert Scale), 43.1% neither agreed nor disagreed (3 on Likert Scale), 24.1% agreed (4 on Likert Scale, and 7.8 % strongly agreed (5 on Likert Scale).

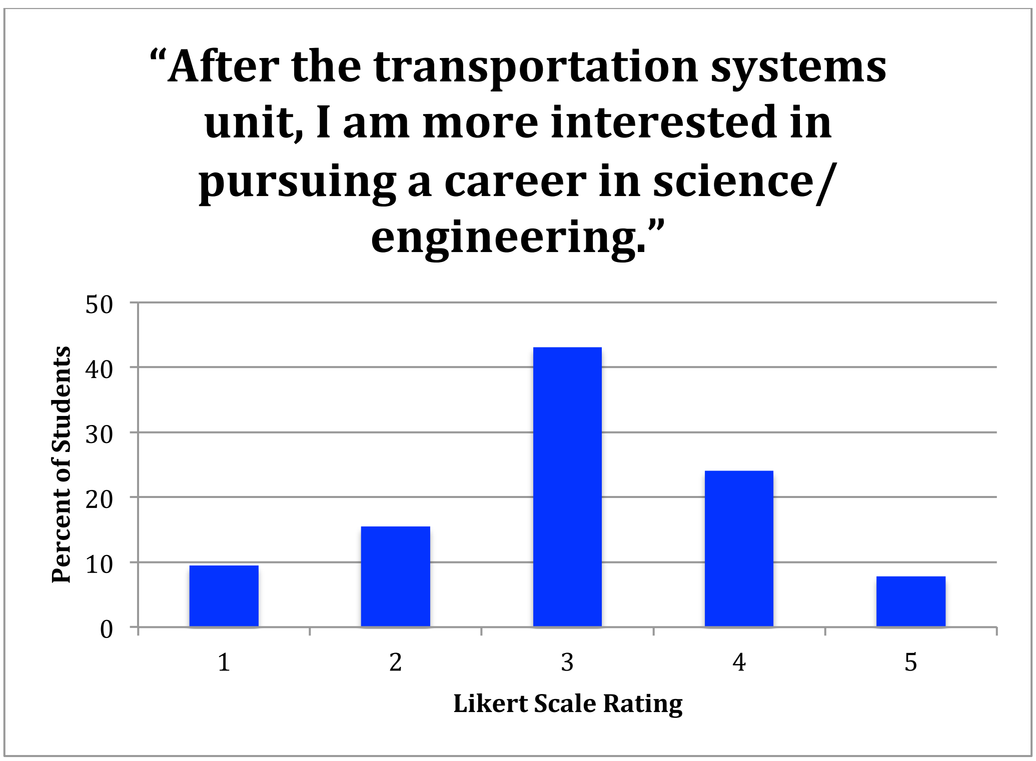


Figure 1. Percentages of students that selected each of the Likert Scale ratings (1-5) for Statement 1.

Statement 2:

The second statement read, " After the transportation systems unit, I can clearly see how my schoolwork is directly related to the real world". As displayed in **Figure 2** (below), 1.7% strongly disagreed with this statement (1 on Likert Scale), 8.6% of students disagreed (2 on Likert Scale), 19.8% neither agreed nor disagreed (3 on Likert Scale), 37.9% agreed (4 on Likert Scale), and 31.9% strongly agreed (5 on Likert Scale).

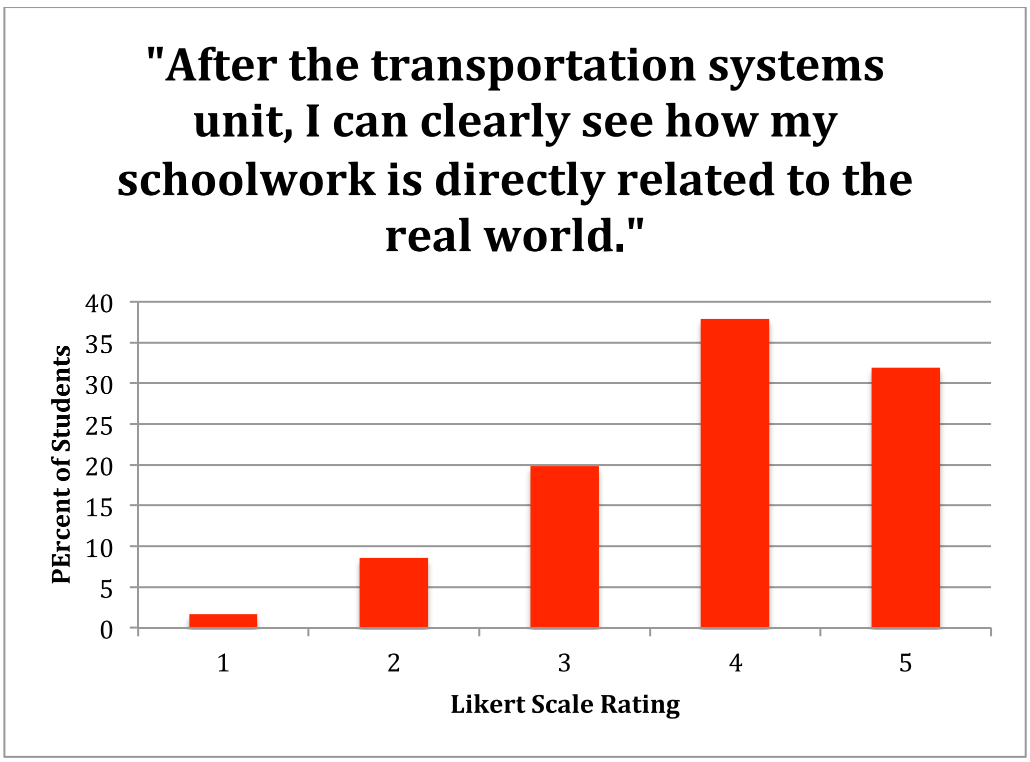


Figure 2. Percentages of students that selected each of the Likert Scale ratings (1-5) for Statement 2.

Statement 3:

The third statement read, " The transportation systems unit allowed me to think creatively and apply critical thinking skills (i.e. making decisions, problem solving, applying knowledge, and reflecting on my work)". As shown in **Figure 3** (below), 1.7% of students strongly disagreed with this statement (1 on Likert Scale), 8.5% disagreed (2 on Likert Scale), 17.1% neither agreed nor disagreed (3 on Likert Scale), 41% agreed (4 on Likert Scale) and 31.6% strongly agreed (5 on Likert Scale).

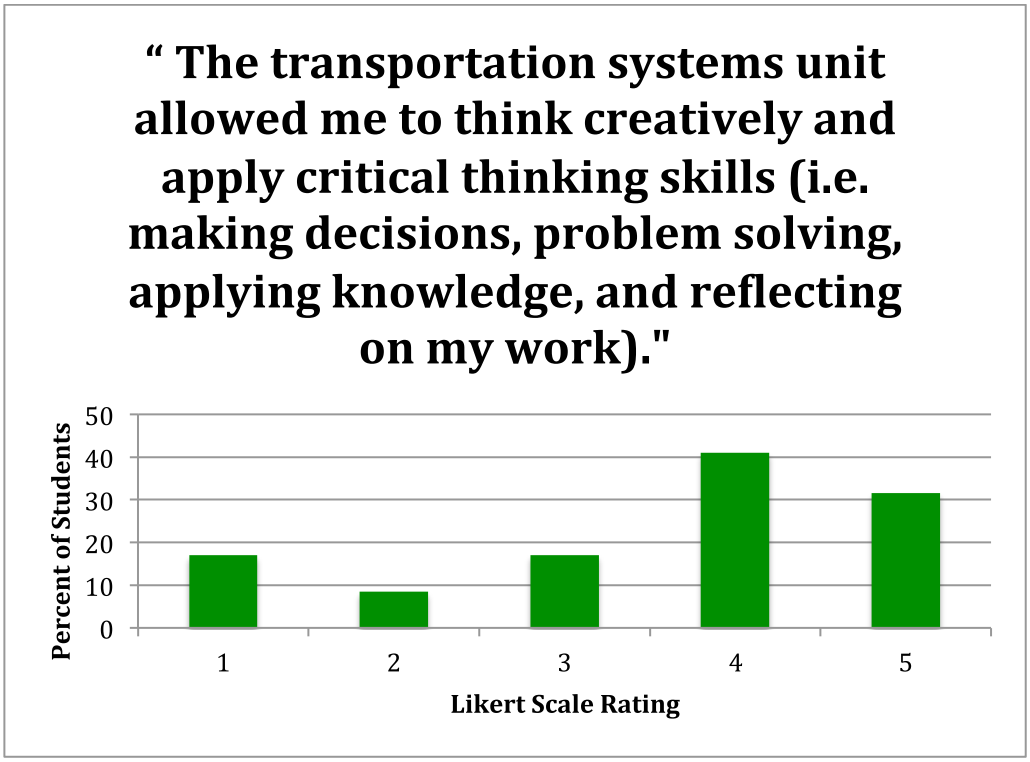


Figure 3. Percentages of students that selected each of the Likert Scale ratings (1-5) for Statement 3.

Discussion/Conclusion:

The 5E instructional method has previously been found to have positive impacts on student achievement as evidenced by increased post-test scores for those exposed to this approach. After analyzing the results of this study, it appears that implementing the 5E method has had a similar effect, seen by the improved post-test scores.

Students that had a percent increase greater than 0% demonstrated a better understanding of the concepts by answering more questions correctly and increasing their score from pre to post test.

Tanner and Allen (2005) describe the theory of conceptual change created by Posner (1982). This theory emphasizes the importance of learning by taking prior misconceptions and changing these into the widely accepted dominant conceptions. It is argued that teaching that incorporates this theory will lead to an understanding of concepts. Students need to clearly see the connection between their prior knowledge and new knowledge. Therefore, it is important that teachers allow students to show prior knowledge, analyze this prior knowledge, clear up any confusion and then allow old and new knowledge to come together to make sense of concepts. According to Tanner and Allen (2005), the inquiry-based instructional method is helpful for applying the conceptual change theory because it allows students to create questions based on prior knowledge and answer these questions by building on prior knowledge.

In the guided inquiry-based module that was created for this thesis, students had to build on prior knowledge, especially for the major project of the unit. At the beginning of the unit (Day 3), students created unique transportation systems and labeled the important parts of the systems. This activity took place before students were introduced to systems and subsystems, specifically transportation systems and their six subsystems. As a result, no student included all six subsystems labeled in their original transportation designs. Some students had parts that belonged to some of the different subsystems, but did not have the correct subsystem labeled or did not have all subsystems present. In the following lesson (Day 4), students were introduced to the six transportation subsystems. For homework this night, students were asked to take their designs home from the previous class and write a sentence explaining each of the six subsystems. If a subsystem was not included in the original transportation design (many were not), students had to explain in a sentence how it could be added. The following day (Day 5), students were then asked to analyze their classmates' designs. They had to determine whether their classmates' original designs had all six subsystems, which subsystems were missing if they did not, and then had to read their sentences to determine if the transportation system would function with the changes made in the sentences completed for homework.

Later in the unit, after students had learned about transportation systems and subsystems and practiced these concepts, they were asked to perform a similar project to the transportation design at the beginning of the unit. Students had to design a unique transportation system to solve a real world issue (See attachments for lesson on Day 6) and create a proposal explaining how it would function effectively to solve the problem of focus. Since the exact activity was not given before and after the unit, scores could not be compared. However, since there was a pre and post test given before and after the guided inquiry instruction, these scores were compared. This thesis argues that the percent increases (Table 1) demonstrate a better understanding of concepts because students were able to build upon prior knowledge throughout the unit and create a connection with their work, which is in line with the theory of conceptual change. They were not simply given numerous facts to memorize, but instead were asked to perform a task that was then built upon to create a final product.

More student attitudes and views toward science became positive from before the unit to after the unit.

It is suggested that when students understand the concepts at hand and are interested in the topics, they will have more positive attitudes toward the subject (Hofstein & Mamlok-Naaman, 2011). An increase in student understanding is evidenced by their percent increases from pre to post test scores above. When students are familiar with concepts being taught it increases their interest, motivation and thus achievement in the classroom (Hofstein & Mamlok-Naaman, 2011). Keeping concepts familiar to students has been practiced throughout this inquiry based unit by relating topics to students' everyday lives. For example, when introducing systems, students were reminded that this is a familiar term that many of them have probably heard of and used before. When asked to recall where they had heard this term before, many students reported having heard it in previous science classes. Students were also informed that there are systems within and surrounding them every day. They were asked to analyze both a bike and a school as a system, both of which are familiar concepts to most if not all students. Also, when delving into transportation systems specifically, students were reminded that each and every one of them uses some transportation system each day in order to get to school, or sports practice, etc. By connecting to everyday life and prior knowledge students feel relevance in their learning, attracting their attention as opposed to completely unfamiliar and seemingly irrelevant concepts that may deter students from becoming interested in the given topics. It is possible, therefore, that the more positive views and ratings for the questions using the Likert Scale are due to the increase in understanding as well as the sense of familiarity with the concepts. The ratings that decreased or were lowered can be explained by the many components that affect attitudes. Student attitudes can change based on their perception of the science teacher, their preference of learning styles and the amount of time actively participating in the lessons (Hofstein & Mamlok-Naaman, 2011). Many of the attitudes and views toward science that did not change from pre to post test could have been due to an already high rating at the pretest due to previous units with similar pedagogical approaches.

Student responses to the additional three reflection questions using the Likert Scale demonstrated that students are not only more aware of and interested in STEM careers, but also more prepared to take on the role of one of these careers by using critical thinking skills and making connections.

Limitations of Study and Plans for the Future:

Since the researcher was the instructor that presented the assignments to the students, specifically the pre and post-test with the Likert Scale questions, there is a possibility of researcher bias, although it is very unlikely. Students were given brief instructions for the pre and post test, and for the Likert Scale questions they were encouraged to answer to the best of their ability, selecting the number that best pertains to their view/attitude. Also, students were ensured that there were no correct/incorrect answers.

Another limitation in this study was having no control group. All five of the participating classes were exposed to the experimental treatment, or the inquiry-based instruction. It would have been helpful to have some classes that were instructed via traditional methods in order to ensure that the observed changes and impacts were indeed due to the implementation of inquiry-based activities. If this study, or a similar one, were to be performed again, a control group would definitely be included.

Finally, the format of the pre and post-test was a limitation in this study. Being a brief, multiple-choice assessment, it was difficult to measure the impact that the inquiry modules had on the students as this assessment did not necessarily require them to apply their knew knowledge as inquiry does. In the future, the project assigned toward the end of the unit would be given in exact form at the beginning of the unit, and the projects would be the pre and post assessment. This would give a better depiction of the impacts of the inquiry instruction that is the focus of the module.

The module created for this thesis was designed for a seventh grade technological systems standard, which is a new standard. By sharing this with local teachers in the surrounding area as well as presenting this work at a National Science Teachers Association (NSTA) Conference or a National Association for Research in Science Teaching (NARST) Conference, it is hopeful that teachers will see the success of this study and implement these modules into their classroom with modification as necessary.

Supplemental Resources 1a:

Teacher Lesson Plans for Unit:

Transportation Systems Unit

Ms. Hannah Walsh

Unit Standard:

7.MS-ETS3-3 (MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Essential Questions for Unit:

1. Why are transportation systems important in everyday life?
2. How do transportation systems function?

Unit Objectives:

Students will be able to…

- Recall and incorporate background knowledge of transportation systems.
- Compare and contrast transportation vehicles as they have appeared over time.
- Identify and explain the purpose of transportation systems
- Construct definitions for systems and subsystems
- Compare and contrast systems and subsystems
- Name and describe the role of the six subsystems of transportation systems
- Apply knowledge of subsystems to explain transportation system designs
- Analyze and evaluate transportation system designs
- Design transportation vehicles to move people and goods in a given scenario

Unit Outline:

Day 1: Pre-test and Introduction to Transportation

Day 2: Transportation and Engineering

Day 3: Systems vs. Subsystems

Day 4: The Six Subsystems of Transportation Systems

Day 5: Subsystem Practice and Check for Understanding

Day 6: Introduction to Challenge and RFP/Team Engineering Design Process

Day 7: Team Engineering Design Process

Day 8: Regroup and finish Team Engineering Design Process

Day 9: Introduction to Individual Online Proposal

Day 10: Individual Proposal

Day 11: Transportation Systems Unit Test and Individual Proposal

Day 12-13: Finish and Submit Online Proposal

Teacher Name: Ms. Walsh
Lesson Title: Day 1, Pre-test and Introduction to Transportation
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3 (MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Recall and incorporate background knowledge of transportation systems.
- Compare and contrast transportation vehicles as they have appeared over time.

<u>Instructional Strategies:</u>

- Engage

<u>Materials:</u>

Teacher: Copies of Transportation Systems Pre-test, notecard for each student

Students: writing utensil, science binders

Lesson:

Opener:

The teacher will wrap up the previous unit of study and introduce the new topic of transportation systems.

Activity:

The teacher will pass out and provide instructions for the Transportation Systems Pre-test. Students will complete the pre-test to show prior knowledge of transportation systems. Students will then watch a quick video that displayed changes in transportation systems as they have appeared throughout history. While watching the video, students will be provided a note card and the teacher will instruct students to write 3 statements while watching. The statements could be similarities between the different transportation systems, differences between the transportation systems or general observations about transportation.

Closer:

Students will be asked to share their thoughts from the video to begin their thinking on transportation systems.

Name:_______________________________________ Block:____________Date:________________

Transportation Systems Pre-Test

Directions: Answer the following questions to the best of your ability. Draw a star directly next to the question number if you completely guessed the answer.

1. A _______________ is a group of parts that work together to perform a function.

A. Suspension
B. Subsystem
C. System
D. Scientist

2. A subsystem is a ______________________.

A. Smaller part of a system
B. System below ground
C. System that is worthless
D. Larger organization above systems

3. What is the **major** function of transportation systems?

A. To move with the fastest speed
B. To transport people and goods
C. To make life as easy as possible
D. To lower death rates

4. How many transportation *subsystems* are there?

A. 1
B. 2
C. 4
D. 6

5. One subsystem of transportation systems is suspension. What is the role of this subsystem?

A. To control the direction that the car is pulled when in motion.
B. To keep certain parts of the system suspenseful rather than well known.
C. To allow hanging items to remain suspended rather than locked down.
D. To support the weight of the transportation system and connect it to its environment

6. When driving to an unknown location, many of us use our GPS. Which subsystem for transportation vehicles would be most responsible in this scenario?

A. Guidance
B. Control
C. Suspension
D. Tension

7. The brakes and steering wheels in cars are a part of what subsystem of transportation vehicles?

A. Guidance
B. Control
C. Suspension
D. Structure

8. Streetlights and traffic signs help transportation systems work smoothly, but are not directly a part of these systems. Which subsystem do these two items belong to?

A. Structure
B. Suspension
C. Support
D. None of the above

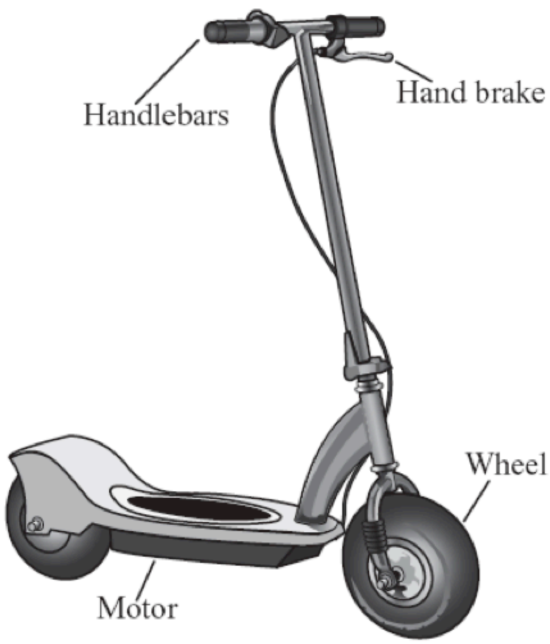
9. When a balloon is filled with air and suddenly released, it will fly around the room as the air escapes. If compared to space transportation, the escaping air is most similar to what subsystem of a spacecraft?

A. Guidance
B. Propulsion
C. Suspension
D. Control

10. The ________________________ subsystem accommodates a vehicle's cargo and forms the basic framework of the vehicle.

A. Structure
B. Suspension
C. Control
D. Support

11. Identify which subsystem (propulsion, guidance, control, or suspension) each of the four labeled parts belongs to and write your answers on the lines.



Directions: For the following statements, write the number (1-5) on the line, which best applies for you.

1= Strongly Disagree
2= Disagree
3= Neither Agree or Disagree
4= Agree
5= Strongly Agree

12. I plan to use science in my future career. ______________________

13. Science plays a role in my everyday life. ______________________

14. There are many career options in science. ______________________

15. Science is a process. ______________________

Teacher Name: Ms. Walsh
Lesson Title: Day 2, Transportation and Engineering
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Compare and contrast transportation vehicles as they have appeared over time.
- Identify and explain the purpose of transportation systems.

Instructional Strategies:

- Engage, explore, explain

Materials:

Teacher: Large pieces of paper (computer or poster paper), Pear Deck presentation prepared (see supplemental resources 1b "Getting Involved in Transportation!"), student copies of note sheet

Students: writing utensil, science binders, Chromebooks

Lesson:

Opener:

Students will begin class with a daily challenge question that will read, "What is the purpose of transportation systems?" Students will then share their answers with their table partners. The teacher will remind students to recall the video from the previous class.

Activity:

The teacher will have students gather in small groups. The teacher will return notecards from the previous class and provide students with a large piece of paper. Students will be asked to organize their group's ideas about transportation that they gathered from the video and from their daily lives. They will also be asked to write the purpose of transportation systems on this sheet. Students will then perform a gallery walk to see their other classmates' brainstorming ideas. The teacher will then gather the class as a whole to discuss common thoughts and ideas from the brainstorming activity. Students will then retrieve their Chromebooks and the teacher will present a Pear Deck presentation. Students will participate in the interactive presentation as well as record notes on a note sheet provided to them. The end of the presentation will mention a project that students will be completing later in the unit.

Closer:

The teacher will quickly introduce the project for the unit to capture student interest. The teacher will explain that students will need a bit more knowledge before being able to take on the challenge.

Getting Involved in Transportation!

Purpose of Transportation:

Four Major Modes of Transportation:

Mode of Transportation	Example

What is an engineer?

Transportation/Vehicle Engineers:

Automotive:

Naval:

Aerospace:

Steps of the Engineering Design Process

1.

2.

3.

4.

5.

6.

7.

Engineers do not always follow the steps of the design process ________________________________.

Engineers also ____ as needed.

Teacher Name: Ms. Walsh
Lesson Title: Day 3, Systems vs. Subsystems
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Construct definitions for systems and subsystems.
- Compare and contrast systems and subsystems.

Instructional Strategies:

- Explore, explain

Materials:

Teacher: Computer paper, Copies of Bike Diagram, Mind Map Copies, Copies of Systems vs. Subsystems Practice (homework)

Students: writing utensil and science binders

Lesson:

Opener:

To begin class, students will have a daily challenge question that will read, "What are systems? Where have you heard this term before?" Students will be asked to share their responses to the class.

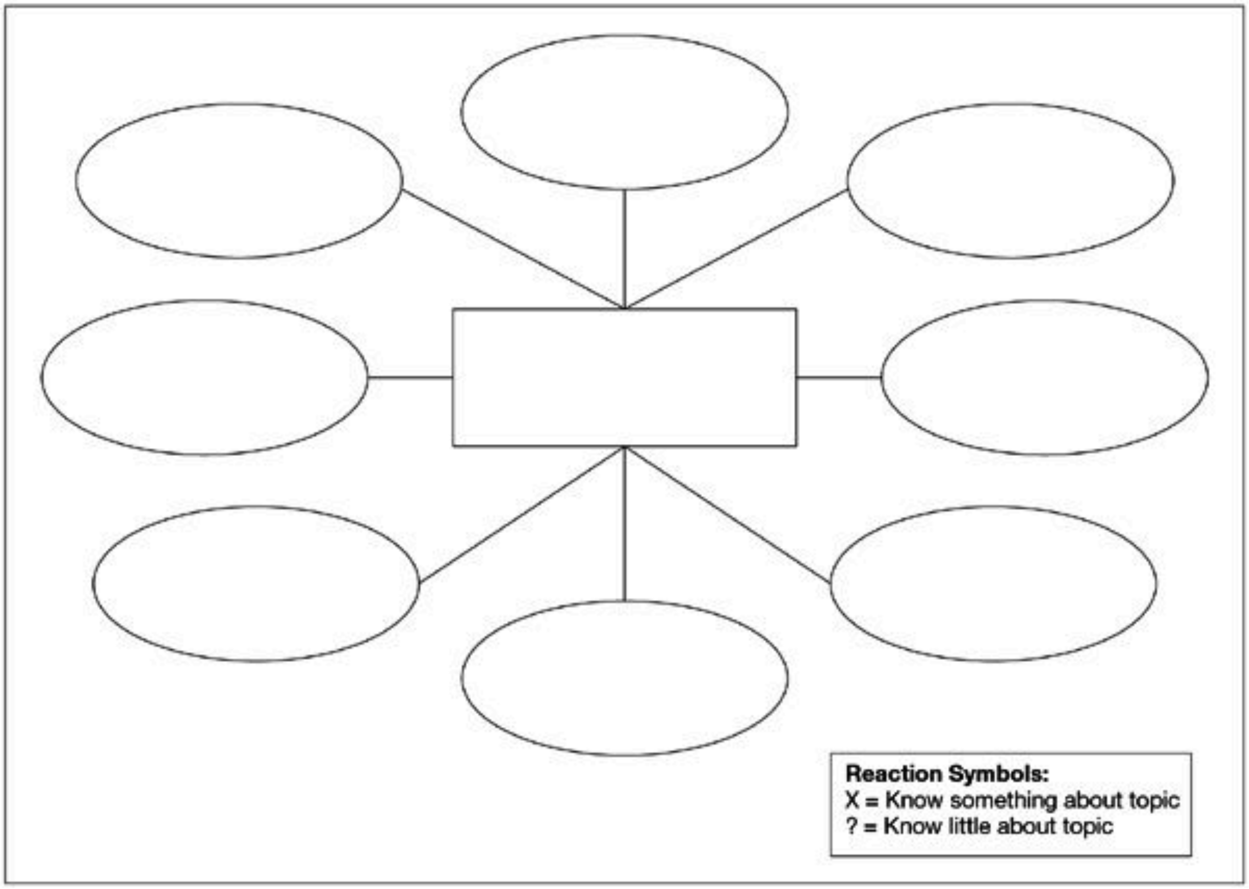
Activity:

Students will be reminded about the different transportation engineer careers they learned about in the previous class. They will be asked to take on one of those engineer careers (automotive, aerospace or naval) and design a unique transportation vehicle on paper and label all parts of their design. Students will be given 5 minutes and then there designs will be collected. The teacher will then explain that students created transportation systems, but what exactly is a system?

The students will be given a copy of a bike diagram. Students will be asked if the bike is a system. The teacher will then have students label the different parts of the bike and the functions of these parts. After providing students ample time the teacher will ask the class as a whole if the bike is a system again and why, leading the students to create a definition for system. The teacher will ask students to name other examples of systems. If not mentioned, the teacher will introduce their school as a system. Students will be given a mind map sheet and asked to put the phrase “My school as a system” in the center box. Students will be asked to work with partners to brainstorm what makes up their school. The teacher will then ask the class as a whole what would happen if different parts of the school were missing. They will be introduced to the term subsystem and will be informed that they just named the subsystems of their school. This will lead students to creating the definition for subsystem. Students will then be asked to think of their school as a subsystem of the larger education system. They will be asked to name other subsystems.

Closer:

The teacher will remind students that for the past couple lessons they have been discussing transportation systems, and ask the students just like all systems, what are transportation systems comprised of? This will lead students to understand that transportation systems are comprised of several subsystems too. They will be looking at these subsystems in more detail next class.


Reaction Symbols:
X = Know something about topic
? = Know little about topic

Name:_______________________________ Block:__________ Date:_________________

Systems vs. Subsystems Practice

1. Name a system you are familiar with below (Not a bike or school).

   System: ____

2. What is the major purpose/ function of this system?

3. List 3 subsystems of the system below and their functions.

Subsystem	Function
1.	
2.	
3.	

4. What would happen to the system as a whole if one of the subsystems above stopped functioning? Be specific.

____
____
____
____
____
____

Teacher Name: Ms. Walsh
Lesson Title: Day 4, The Six Subsystems of Transportation Systems
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Name and describe the role of the six subsystems of transportation systems

Instructional Strategies:

- Explore, explain

Materials:

Teacher: The Six Transportation Subsystems Note Packet copies, PowerPoint slides for stations, PowerPoint presentation with correct definitions prepared (see supplemental resources 1c "The Six Transportation Subsystems" for station slides and correct definitions).

Students: writing utensil and science binders

Lesson:

Opener:

Students will begin class with a daily challenge that asks, "What is a subsystem?" and "Name two subsystems of transportation systems". Students should have the correct definition for subsystems from the previous class. Students will have to think about what subsystems are and try to come up with two subsystem names specifically for transportation systems. Students do not have to be completely correct; the teacher will accept all answers. Students will be reminded that they defined systems and subsystems last class. Transportation systems are composed of subsystems as well.

Activity:

Students will be given a note packet and the teacher will review and present a PowerPoint for students to write the definitions for systems and subsystems again. The teacher will then tell students the names of the six different transportation subsystems. The teacher will then inform students that they need to find out what these subsystems are, and to do so they will be put into groups/stations The teacher will count students off by 12 to create 12 small groups. The teacher will have two sets of the six subsystems in order to spread students out more and more the activity along quickly. At each station, students will find a print out of a PowerPoint slide that has a subsystem name, some examples of the subsystem as well as some pictures. Students will need to write the examples of each subsystem on their note sheets and will also have to create a definition for the subsystem based on the name and examples. Their note sheets will have a box for their definition as well as a correct definition box. Students will spend a maximum of two minutes at each station. When students have moved through each of the six different stations, the teacher will have students return to their original seats. The teacher will walk students through a PowerPoint, asking for volunteers to share their definitions and then giving students the correct definitions. The teacher will then return student transportation system designs from the previous class. The teacher will direct students to review their designs. On the blank side of their paper, students will be asked to write one sentence explaining each of the six subsystems in their design. If their designs do not include one of the subsystems, students will be asked to explain how their design could be improved in order to include all parts. Students will be able to complete this task for homework if needed.

Closer:

The teacher will ask students to share their experiences from this activity. The students will be asked whether they had a majority of the six subsystems in their original designs. Which subsystems were completely forgotten, which ones were most popular? Which subsystem is most important?

Name:________________________________ Block:__________ Date:_________________

The Six Transportation Subsystems

System-

↓ ↓ ↓

Subsystem-

Transportation Subsystems:

1.

2.

3.

4.

5.

6.

1. Structure

Examples:

-
-
-
-

Your Definition:	**Correct Definition:**

2. Suspension

Examples:

-
-
-
-

Your Definition:	**Correct Definition:**

3. Control

Examples:

-
-
-
-

Your Definition:	**Correct Definition:**

4. Guidance

Examples:

-
-
-
-
-

Your Definition:	Correct Definition:

5. Propulsion

Examples:

-
-
-
-
-

Your Definition:	Correct Definition:

6. Support

Examples:

-
-
-
-
-

Your Definition:	Correct Definition:

Teacher Name: Ms. Walsh
Lesson Title: Day 5, Subsystem Practice and Check for Understanding
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Name and describe the role of the six subsystems of transportation systems
- Analyze and evaluate transportation system designs

Instructional Strategies:

- Explain, evaluate

Materials:

Teacher: "Designs-Will they get the job done?" copies, Subsystem Puzzles, Formative assessment slides prepared (see supplemental resources 1d "Taking on the role & responsibilities of a transportation engineer!") , key chains with letters A-D for each student

Students: writing utensil and science binders

Lesson:

Opener:

Students will begin class with a daily challenge that reads, "Name one subsystem of transportation systems and its function. Students will be expected to go back to their notes from the previous class and should have the correct answer for this question. Students will be informed that they are going to be taking on the role and responsibilities of a transportation engineer in their upcoming project, and this lesson will determine if they are ready to take on this role.

Activity:

Students will be asked to have their homework out (explanations for subsystems in designs) and given a worksheet titled "Designs-will they get the job done?" The teacher will review the questions on the worksheet: Looking at the student's design, are all transportation subsystems present? If no, which subsystems are missing? Will the transportation system function effectively? How do you know? The students will be asked to remind the class what is the purpose of transportation, how many transportation subsystems there are in total, and how many of these subsystems must be present in order for the transportation system to function. The teacher will then explain that students will be passing their homework (design and explanation sentences) around the classroom to different students until they are told to stop. When students are stopped, they will look at the design in front of them and answer the questions on their sheet in complete sentences. After 2-3 minutes, students will be asked to pass again and will perform the activity a second time, with a different design. Students will then hand in their activity sheets along with their homework. They will then asked to work with a partner to complete a transportation subsystem puzzle. Some of the puzzle pieces will have the names of the different subsystems, some will have the definition/purpose of the subsystems and some will have examples of the different subsystems. Students will have to work with their partner to arrange the pieces in the order of name, definition, and example for all six subsystems. The team that completes the puzzle the quickest and with 100% accuracy will receive a reward. The teacher will then ask for six different volunteers to give the name, definition and example for one subsystem, so students know what their puzzles should look like.

Closer:

The teacher will have a series of slides projected to the class. The title slide will say, “Taking on the Roles and Responsibilities of a Transportation Engineer…Are you ready?” Students will then be asked a series of questions (one at a time) regarding transportation subsystems, modes of transportation, purpose of transportation and transportation engineering. The questions will have choices A-D. The students will have to choose which answer they believe is correct, and after allowing enough time, the teacher will ask students to show their answers on their key chains to the teacher. During this activity, the teacher will take note of students that show a misunderstanding of concepts and these students will be pulled aside during the next class to check-in and make sure they understand the concepts.

Name: ________________________________ Block: _________ Date: __________________

Designs- Will they get the job done?

1.

A. Look at the student's design. Does the student's design have all six transportation subsystems present?

B. If no, which subsystems are missing?

C. Read the student's sentences. Based on the explanation sentences and changes the student would make, would this transportation system function?

D. How do you know?

2.

A. Look at the student's design. Does the student's design have all six transportation subsystems present?

B. If no, which subsystems are missing?

C. Read the student's sentences. Based on the explanation sentences and changes the student would make, would this transportation system function?

D. How do you know?

3.
A. Look at the student's design. Does the student's design have all six transportation subsystems present?

B. If no, which subsystems are missing?

C. Read the student's sentences. Based on the explanation sentences and changes the student would make, would this transportation system function?

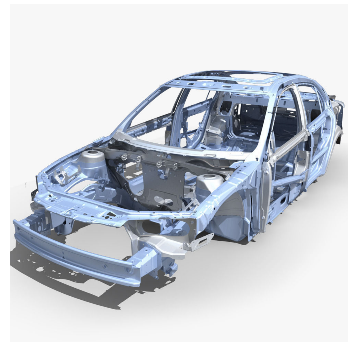
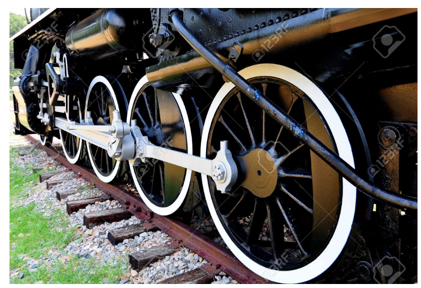
D. How do you know?

4.
A. Look at the student's design. Does the student's design have all six transportation subsystems present?

B. If no, which subsystems are missing?

C. Read the student's sentences. Based on the explanation sentences and changes the student would make, would this transportation system function?

D. How do you know?

Structure	Accommodates the vehicle's cargo and forms the basic framework for the transportation system	
Suspension	Connects the transportation system to its environment	
Control	Determines the speed and direction of the transportation system/vehicle	
Guidance	Provides assistance to the vehicle in staying on course	

Propulsion	Provides movement for a vehicle; drives or pushes a vehicle forward	
Support	Items that aid the transportation system and its function, but are not directly a part of it	

Teacher Name: Ms. Walsh
Lesson Title: Day 6, Introduction to Challenge and RFP/Team Engineering Design Process
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Design an effective transportation system to move people/goods in a given scenario

Instructional Strategies:

- Extend

Materials:

Teacher: Subsystem Practice sheet copies, "RFP-Sell *Your* Design" packet copies

Students: writing utensil and science binders

Lesson:

Opener:

Students will begin class with a different daily challenge. They will be given a sheet with a chart that has the six subsystem names. Students will have to fill out the chart with the functions and examples of the subsystems by using their notes. The teacher will then review the sheet and ask students if they have any questions.

Activity:

Students will be given the "RFP-Sell Your Design" packets. The teacher will review their challenge and the real world issues that the students will be choosing to design a transportation system to resolve. The teacher will then walk the students through the project packet and requirements. The students will be placed in groups of three based on their academic standing and ability to work well in a group. The groups will be planned prior to class. For the remainder of class, students will work through their project packets to pick a transportation issue, design a transportation system and explain it. The teacher will circulate the room to listen to student ideas and answer any specific questions.

Closer:

The teacher will inform students that they will be working in their project packets the following class as well and should continue to think about ideas for their designs.

Name:______________________________________ Block:___________Date:_________________________

RFP- Sell *Your* Design

The U.S. Department of Transportation is a government department whose mission is to "Serve the United States by ensuring a fast, safe, efficient, accessible, and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future." This department will often seek engineers (automotive, naval, or aerospace) to help meet the need of their mission by designing and developing new transportation systems, and they need your help now!

Your Challenge:

Your team must develop a new transportation system and persuade the U.S. Department of Transportation that your system will effectively solve the problem of focus. The team that has the strongest persuasion and best resolves the need, will receive full funding to develop their transportation system!

1. **Directions:** Below is a list of serious transportation issues currently affecting the U.S. Read all scenarios and circle the **one** that your group is going to design a transportation system to resolve.

Target Area	Who/what is being transported?	Brief summary of scenario	Moving Through or Over…
1. Boston	People	Close to 100,000 vehicles drive into and out of Boston each day. Boston roadways were not built to handle this amount of traffic and thus this city has one of the highest daily commute times in all of the U.S. How could this be solved?	Land
2. Texas	Food, water, candles, lanterns and other survival items	Hurricane Harvey recently caused high flood waters in certain areas of Texas. Flood waters still remain around many homes and residents are still unable to leave. The Red Cross needs to get supplies to these homes. How could this be solved?	Flooded Land
3. Puerto Rico	People	Hurricane Maria recently caused thousands of dollars of road damage in Puerto Rico and caused electricity to be lost entirely. Thousands of residents need to leave Puerto Rico, and move across the Caribbean Sea to Florida to seek safety. How could this be solved?	Ocean

4. Mars	Food, water, clothing and other survival items	A NASA mission aims to have humans inhabiting Mars by the 2030s. If humans begin to live on Mars, they will need food, water, clothing, etc. occasionally brought to them from Earth. How could this be solved?	Space

2. Identify the **specific** need:

____
____
____
____

3. Career Choice (circle one): automotive engineer naval engineer aerospace engineer

4. Brainstorm: Draw or describe the different parts that you think will be helpful in your vehicle design.

5. Develop Possible Solutions: Sketch and label or describe two possible design solutions for your problem:

A.

B.

6. Select a Promising Solution (you may use one from above or combine the two): Draw this design (to be presented to the U.S. Department of Transportation) in great detail and label all parts.

Vehicle Name:____

\

7. Test and Evaluate: The Department of U.S. Transportation is only able to fund the building of one vehicle. Since you are not able to test and evaluate your vehicle, you must explain in detail below the six subsystems and their functions in your specific vehicle to demonstrate that your vehicle would function effectively.

Structure:

____

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Suspension:

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Control:

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Guidance:

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Propulsion:

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Support:

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Signature to Begin Proposal:____

Good Luck!

Teacher Name: Ms. Walsh
Lesson Title: Day 7, Team Engineering Design Process
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Design an effective transportation system to move people/goods in a given scenario

Instructional Strategies:

- Extend

Materials:

Teacher: short video links, and students' "RFP-Sell Your Design" packets

Students: writing utensil and science binders

Lesson:

Opener:

To begin class, students will be reminded that they had worked in their design groups yesterday and should have picked the real world issue that they are going to be focusing on for the project. The teacher will then present four short video clips that show the four issues in actions. The students will be instructed to take brief notes/observations down in their packets when watching the video pertaining to the issue of choice.

Activity:

Students will be asked to get back into their design groups from the previous class and continue working on the team engineering design process. The teacher will circulate the room to listen to student ideas and answer any specific questions that arise.

Closer:

Students will be informed that they will only have 15-20 minutes the next class to get back into their groups before starting the individual part of the project. They should continue to put thought into the project and organize these thoughts to put them into place the next class in the short amount of time.

Teacher Name: Ms. Walsh
Lesson Title: Day 8, Regroup and Finish Team Engineering Design Process
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Design an effective transportation system to move people/goods in a given scenario

Instructional Strategies:

- Extend

Materials:

Teacher: student copies of RFP- Sell *Your* Design Packets from last class

Students: writing utensil and science binders

Lesson:

Student "RFP-Sell *Your* Design" Packets will be returned to them at the start of class. They will be directed to gather in their groups, and will be given the class period to complete their packets.

Teacher Name: Ms. Walsh
Lesson Title: Day 9, Introduction to Individual Proposal
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Design an effective transportation system to move people/goods in a given scenario

Instructional Strategies:

- Extend

Materials:

Teacher: student copies of RFP- Sell *Your* Design Packets from last class, Individual Proposal Guidelines and Rubric, Chromebooks

Students: writing utensil and science binders

Lesson:

Teacher will pass back group packets from previous class. The teacher will then pass out proposal guidelines and rubrics to each student and review the different requirements and how students will be graded. The teacher will then direct students how to download Web Paint app and allow them to practice using this tool before setting them on a task. After a couple minutes students will be directed to open their group packets to their final transportation system design.

Students will then be asked to create their design using Web Paint. At the end of class, students will be directed to save their transportation designs, and will sign out of Chromebooks. The teacher will collect all student project papers.

Name:____Block:________Date:________________

RFP- Sell *Your* Design

The U.S. Department of Transportation is a government department whose mission is to "Serve the United States by ensuring a fast, safe, efficient, accessible, and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future." This department will often seek engineers (automotive, naval, or aerospace) to help meet the need of their mission by designing and developing new transportation systems, and they need your help now!

Your Challenge:

Your team must develop a new transportation system and persuade the U.S. Department of Transportation that your system will effectively solve the problem of focus. The team that has the strongest persuasion and best resolves the need, will receive full funding to develop their transportation system!

Programs for online proposal: Google Docs, Web Paint, Canva

Proposal Requirements:

______ Your name, Career Choice

______ Identify and explain the specific issue or need for this design

______ Name of your vehicle design

______ Detailed vehicle design-labeled and has color (draw on Google Docs with Web Paint)

______ Explanation of how your transportation vehicle functions as a system
- ______All **six** subsystems are in design and explained in detail

______ Persuasion Statement
- ______Come up with a scientific argument for why the U.S. Department of Transportation should fund your design specifically
- ______Argument must be written in claim evidence, reasoning format
- ______Argument should demonstrate that the design meets the need

Proposal Rubric

_______________/100

Category	20	15	10	5
Requirements	All requirements are present and completed thoroughly; demonstrates expertise of concepts	All requirements are present but not completed thoroughly; demonstrates a good understanding of concepts	1-2 requirements are missing or incomplete; demonstrates some misunderstandings of concepts	More than 2 requirements are missing or incomplete; demonstrates a lack of understanding
Effort and Creativity	Design is original and put together in a surprising way	Design contains original ideas, but also displays many already existing features	There is little creativity and originality in design.	Shows no creativity, design is not original
Organization/ Presentation	Proposal is highly organized into appropriate sections and order; uses font size, color and graphics that enhance the proposal presentation	Proposal is organized and makes good use of font size, color and graphics to enhance proposal presentation	Proposal does not have clear, organized sections and font size, color and graphics is sometimes distracting	Proposal completely lacks organization and information is difficult to find and font size, color and graphics are completely distracting
Persuasion	Makes a very accurate and clear claim, evidence and reasoning argument that has specific evidence that ties the need to the design	Makes an accurate and clear claim, evidence and reasoning argument that ties the need to the design	Makes an argument using claim, evidence and reasoning, but does not connect the need and design	Incomplete claim, evidence and reasoning argument
Mechanics	No misspellings or grammatical errors; uses appropriate scientific vocabulary for entire proposal	Maximum of three misspellings or grammatical errors; uses scientific vocabulary for a majority of the proposal	Four misspellings or grammatical errors; uses minimal scientific vocabulary in proposal	More than 4 misspellings or grammatical errors; uses very minimal to no scientific vocabulary in proposal

Teacher Name: Ms. Walsh
Lesson Title: Day 10, Individual Proposal
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Design an effective transportation system to move people/goods in a given scenario

Instructional Strategies:

- Extend

Materials:

Teacher: student copies of RFP- Sell *Your* Design Packets from last class, Individual Proposal Guidelines and Rubric, Chromebooks

Students: writing utensil and science binders

Lesson:

The teacher will have students sign into their Chromebooks immediately upon entering the classroom. The students will be directed to Google Classroom to find the link to canva.com. The teacher will then walk students through the steps of opening a new blank proposal poster on the Canva site. Once this is accomplished, the teacher will ask students to open a new tab to the Google Doc that their transportation designs saved to. By the end of class the teacher will instruct students how to move their transportation design paintings form the Google Doc to their

Canva proposal poster. The students will be informed how to save on Canva, and will then be directed to sign out. They will put their Chromebooks back, and the teacher will collect all student project papers.

Teacher Name: Ms. Walsh
Lesson Title: Day 11, Transportation Systems Unit Test/Individual Proposal
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Design a persuasive proposal to support their transportation system design

Instructional Strategies:

- Extend
- Evaluate

Materials:

Teacher: student copies of project papers, student copies of Transportation Systems Unit Test, Chromebooks

Students: writing utensil and science binders

Lesson:

Students will be directed to prepare their desks for their unit test. The teacher will then hand the Transportation Systems Unit Test out to students and review specific instructions. Students will complete their handwritten tests and hand them in at the front of the classroom. They will then retrieve their Chromebooks, sign in and work on their individual proposals. Once all students complete their test, student project papers will be returned to students. Students will work on their individual proposals for the remainder of class. At the end of class, students will sign out of Chromebooks and return their project papers to the teacher.

Name:____ Block:____________Date:________________

Transportation Systems Unit Test

Directions: Answer the following questions to the best of your ability.

1. A ________________ is a group of parts that work together to perform a function.

A. Suspension
B. Subsystem
C. System
D. Scientist

2. A subsystem is a _______________________.

A. Smaller part of a system
B. System below ground
C. System that is worthless
D. Larger organization above systems

3. What is the **major** function of transportation systems?

A. To move with the fastest speed
B. To transport people and goods
C. To make life as easy as possible
D. To lower death rates

4. How many transportation *subsystems* are there?

A. 1
B. 2
C. 4
D. 6

5. One subsystem of transportation systems is suspension. What is the role of this subsystem?

A. To control the direction that the car is pulled when in motion.
B. To keep certain parts of the system suspenseful rather than well known.
C. To allow hanging items to remain suspended rather than locked down.
D. To support the weight of the transportation system and connect it to its environment

6. When driving to an unknown location, many of us use our GPS. Which subsystem for transportation vehicles would be most responsible in this scenario?

A. Guidance
B. Control
C. Suspension
D. Tension

7. The brakes and steering wheels in cars are a part of what subsystem of transportation vehicles?

A. Guidance
B. Control
C. Suspension
D. Structure

8. Streetlights and traffic signs help transportation systems work smoothly, but are not directly a part of these systems. Which subsystem do these two items belong to?

A. Structure
B. Suspension
C. Support
D. None of the above

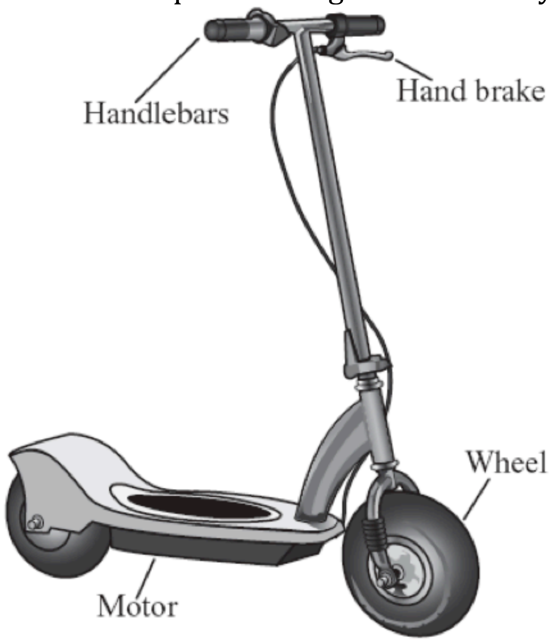
9. When a balloon is filled with air and suddenly released, it will fly around the room as the air escapes. If compared to space transportation, the escaping air is most similar to what subsystem of a spacecraft?

A. Guidance
B. Propulsion
C. Suspension
D. Control

10. The ________________________ subsystem accommodates a vehicle's cargo and forms the basic framework of the vehicle.

A. Structure
B. Suspension
C. Control
D. Support

11. Identify which subsystem (propulsion, guidance, control, or suspension) each of the four labeled parts belongs to and write your answers on the lines.



Directions: For the following statements, write the number (1-5) on the line, which best applies for you.

1= Strongly Disagree
2= Disagree
3= Neither Agree or Disagree
4= Agree
5= Strongly Agree

12. I plan to use science in my future career. ____________________

13. Science plays a role in my everyday life. ____________________

14. There are many career options in science. ____________________

15. Science is a process. ____________________

Directions: For the following statements, reflect on this past transportation systems unit and write the number (1-5) on the line, which best applies for you.

1= Strongly Disagree
2= Disagree
3= Neither Agree or Disagree
4= Agree
5= Strongly Agree

16. After the transportation systems unit, I am more interested in pursuing a career in science/engineering.

____

17. After the transportation systems unit, I can clearly see how my schoolwork is directly related to the real world.

____

18. The transportation systems unit allowed me to think creatively and apply critical thinking skills (i.e. making decisions, problem solving, applying knowledge, and reflecting on my work).

____

Teacher Name: Ms. Walsh
Lesson Title: Day 12, Individual Proposal
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Design a persuasive proposal to support their transportation system design.

Instructional Strategies:

- Extend
- Evaluate

Materials:

Teacher: student copies of project papers, Chromebooks, Canva Checklist

Students: writing utensil and science binders

Lesson:

Student project papers will be returned to students. The teacher will hand out a checklist specific for Canva and will review briefly with students. The teacher will inform students that they need to refer to this checklist and figure out the program on their own for the day. The teacher will then show examples of a similar project using Canva to show students what they are able to do on Canva and what is expected of them. The teacher will then set students to work on their proposals and will circulate the room to observe student work and hear student ideas.

Name: ______________________________Block:__________Date:__________________

Proposal – Canva Checklist

_____ Name of Design

- Should be the center focus of your proposal
- Large font and eye catching
- Stands out
- First thing noticed on the page
- This is what you want the US Department of Transportation to remember…and fund!

_____ Your Name

- Should include your first and last name
- Should be followed by your career position
- This way the US D.O.T knows who designed this device and what type of engineer they are hiring

_____ Need for the design

- Should grab the reader's attention, catchy title to lure them in
- Comes before the design itself
- The need for the design should explain to the reader that this issue is serious and a solution is desperately needed; it is urgent
- Add color, titles, font, etc.

_____ Design Drawing

- Web Paint Design uploaded

_____ Explanation of Subsystems

- Should be brief
- Broken up into each subsystem
- Quick, easy explanations of parts in design and subsystems they belong to (if not detailed or clear in design)

_____ Persuasion Statement

- Should be in paragraph form
- Can be color coded into Claim, Evidence, and Reasoning
- Makes a confident statement for the claim that persuades the U.S Department of Transportation that your design will effectively solve the specific issue
- Has a lot of Evidence-Details are here!
- Evidence =Persuasion
- Reasoning ties your evidence to your claim; how does your evidence support your claim that your design meets the need?

_____ Other

- You may use outside/additional images as long as they are appropriate and do not distract from your design (Be as creative as possible)

Teacher Name: Ms. Walsh
Lesson Title: Day 13, Individual Proposal
Subject: Middle School Science, Technology/Engineering
Grade: Seventh Grade
Time: 50 minute-1 hour block

Standards:

7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.

Objectives:

Students will be able to…

- Design a persuasive proposal to support their transportation system design.

Instructional Strategies:

- Extend
- Evaluate

Materials:

Teacher: student copies of all project papers, Chromebooks

Students: writing utensil and science binders

Lesson:

Students will be directed to get their Chromebooks upon entering the classroom and get signed in and onto Canva. Students project papers will be returned. The students will be informed that they need to refer to all their project papers and complete their proposals and submit by the end of class. Project papers will be collected at the end of class and students will sign out and return Chromebooks.

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Getting Involved In Transportation!

Slide 1: Projector and Student View

Students will see this on the projector

Think back to yesterday's video and your discussions. Also think about your daily life. In one sentence, explain the purpose of transportation.

abc

Slide 2: Projector and Student View

Students will see this on the projector and use their devices to enter text

Slide 3: Projector and Student View

Students will see this on the projector and use their devices to enter text

Purpose of Transportation

The purpose of transportation systems is to move people and goods from one location to another using a variety of vehicles and devices.

Slide 4: Projector and Student View

Students will see this on the projector

Sketch images to represent the four major modes of transportation.

Slide 5: Projector View

Students will see this on the projector

Sketch images to represent the four major modes of transportation.

Slide 5: Student View

Students will see this on their devices and draw on it

Four Major Modes of Transportation

1. Land
2. Water
3. Air
4. Space

Slide 6: Projector and Student View

Students will see this on the projector

Engineers

Engineers are...

-Innovators
-Researchers
-Problem Solvers
-Inventors
-Creators

Engineers use basic knowledge in mathematics and science, and apply their technical knowledge to develop, design and implement new processes, products and systems that make our everyday lives possible.

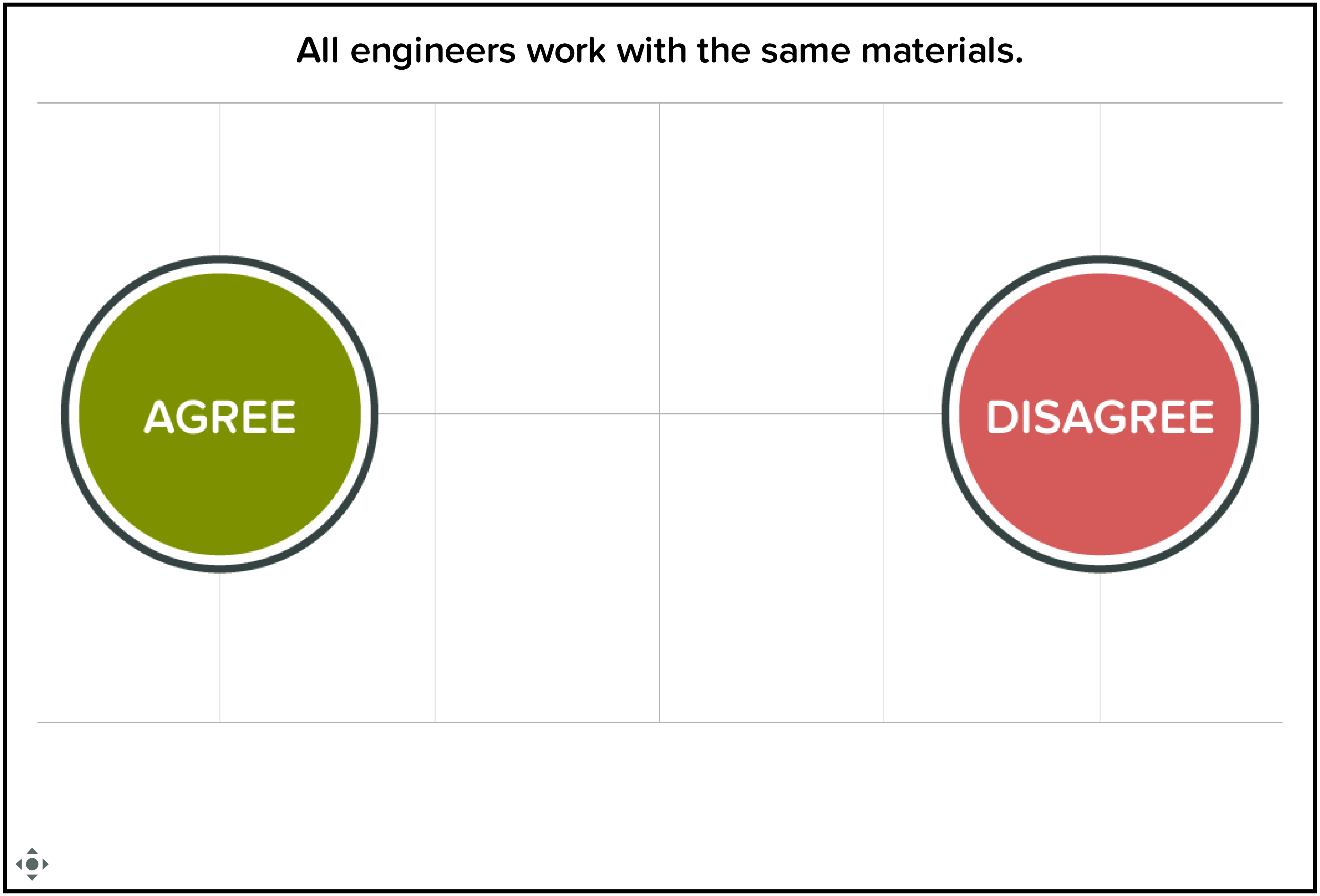
Slide 7: Projector and Student View

Students will see this on the projector

All engineers work with the same materials.

Slide 8: Projector View

Students will see this on the projector



Slide 8: Student View

Students will see this on their devices and drag items on it

Engineers make our quality of life possible!

-Electrical Engineer
-Mechanical Engineer
-Automotive Engineer
-Biomedical Engineer
-Agricultural Engineer
-Architectural Engineer
-Computer Engineer
-Aerospace Engineer
-Naval Engineer

Slide 9: Projector and Student View

Students will see this on the projector

Transportation/Vehicle Engineering

Automotive Engineers: focus on motorcycles, automobiles and trucks (Land)

Naval Engineers: focus on marine vessels/ships (Water)

Aerospace Engineers: focus on aircraft and spacecraft (Air & Space)

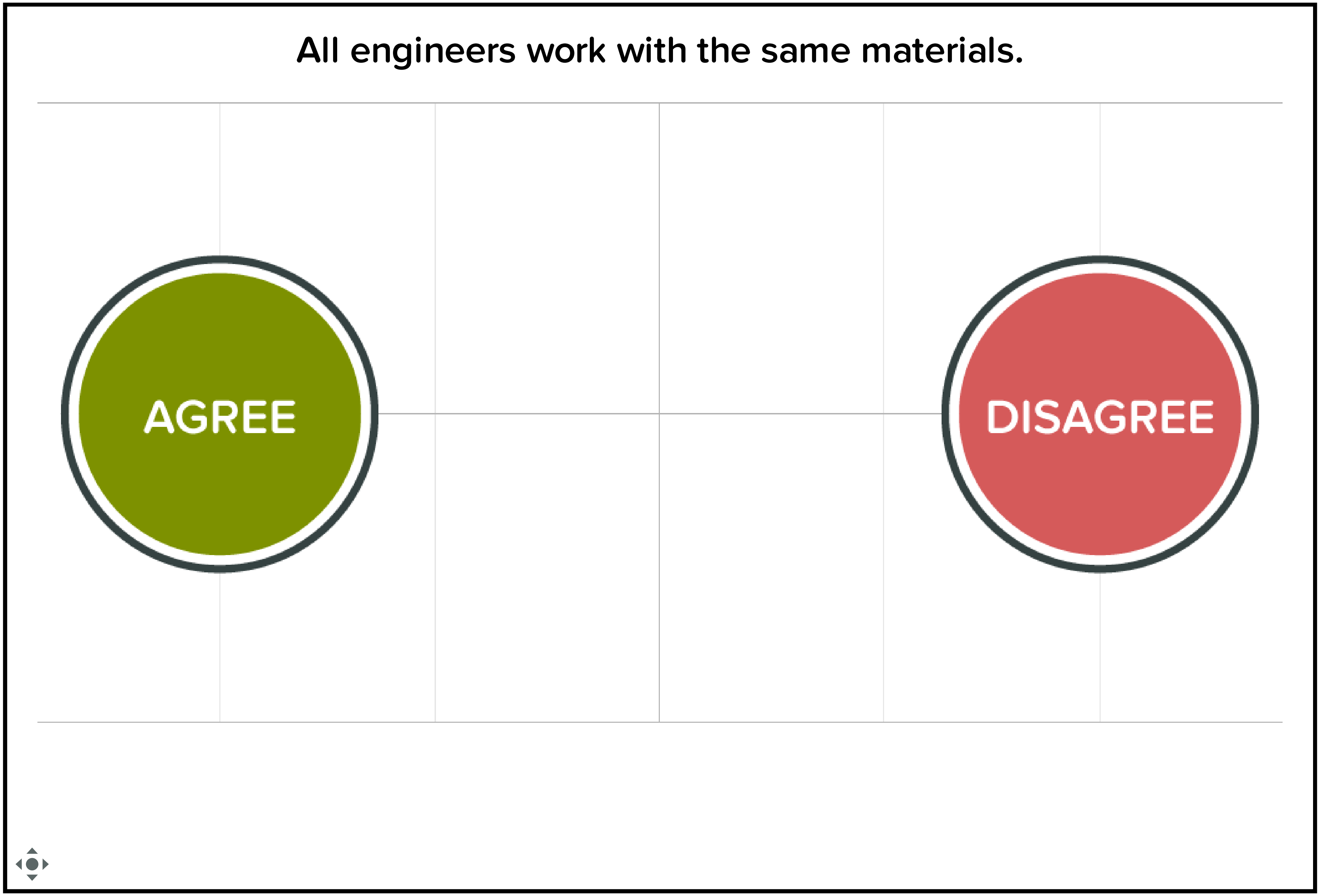
Slide 10: Projector and Student View

Students will see this on the projector

All engineers work with the same materials.

Slide 11: Projector View

Students will see this on the projector



Slide 11: Student View

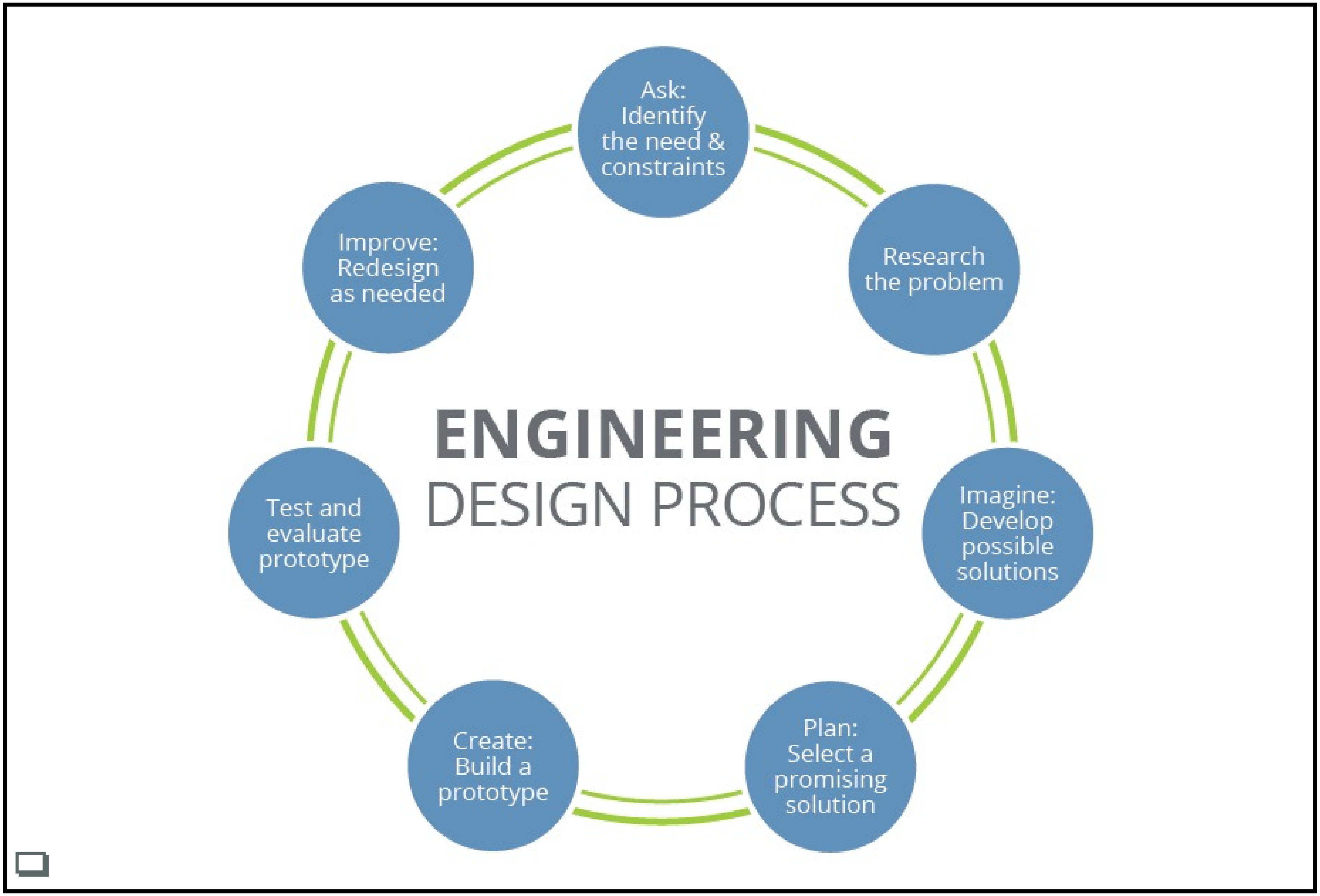
Students will see this on their devices and drag items on it

What are the steps of the Engineering Design Process?

abc

Slide 12: Projector and Student View

Students will see this on the projector and use their devices to enter text



Slide 13: Projector and Student View

Students will see this on the projector

The design process follows a strict order.

Slide 14: Projector View

Students will see this on the projector

The design process follows a strict order.

Slide 14: Student View

Students will see this on their devices and drag items on it

Engineers do not always follow the steps of the design process in order.

Engineers also repeat steps as needed.

Slide 15: Projector and Student View

Students will see this on the projector

I am confident that I can take the role of a transportation/vehicle engineer in our next project!

Slide 16: Projector View

Students will see this on the projector

I am confident that I can take the role of a transportation/vehicle engineer in our next project!

Slide 16: Student View

Students will see this on their devices and drag items on it

The Six Transportation Subsystems

Ms. Walsh

System vs. Subsystem

- System- A group of parts working together to perform a function

- Subsystem-A smaller part of a system

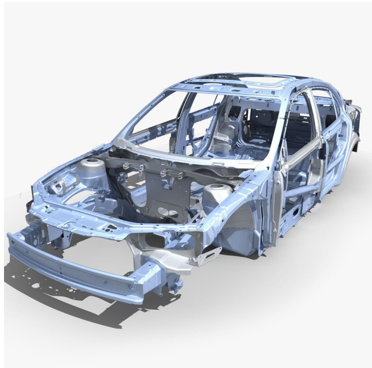
The Six Subsystems

- Structure
- Suspension
- Control
- Guidance
- Propulsion
- Support

Subsystem: Structure

- Definition: ? ? ?

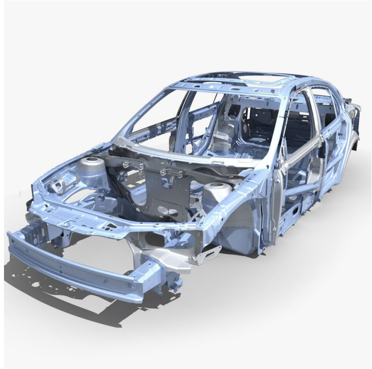
- Examples:
  - Car Frame
  - Boat Hull
  - Bike Frame
  - Airplane Cabin



Subsystem: Structure

- Definition: Accommodates the vehicle's cargo and forms the basic framework for the transportation system

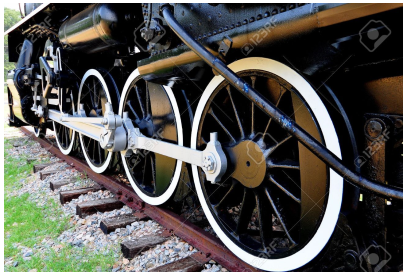
- Examples:
  - Car Frame
  - Boat Hull
  - Bike Frame
  - Airplane Cabin



Subsystem: Suspension

- Definition: ? ? ?

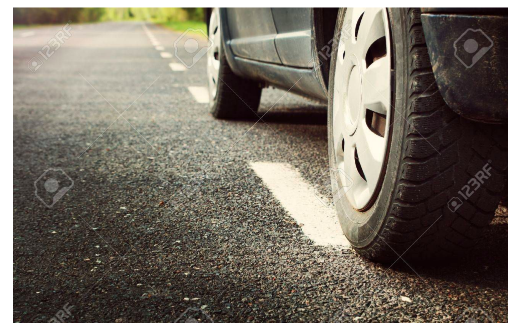
- Examples:
  - Automobile: Tires on the Road
  - Airplane: Wings in the Air
  - Train: Wheels on the Track
  - Boat: Hull on the Water



Subsystem: Suspension

- Definition: Connects the transportation system to its environment

- Examples:
  - Automobile: Tires on the Road
  - Airplane: Wings in the Air
  - Train: Wheels on the Track
  - Boat: Hull on the Water



Subsystem: Control

- Definition: ? ? ?

- Examples:
  - Brakes
  - Steering Wheel
  - Handle Bars
  - Rudder on Boats and Planes

Subsystem: Control

- Definition: Determines the speed and direction of the transportation system/vehicle

- Examples:
  - Brakes
  - Steering Wheel
  - Handle Bars
  - Rudder on Boats and Planes

Subsystem: Guidance

- Definition: ? ? ?

- Examples:
  - Compass
  - Headlights
  - Turn Signals
  - GPS
  - Maps

Subsystem: Guidance

- Definition: Provides assistance to the vehicle in staying on course

- Examples:
  – Compass
  – Headlights
  – Turn Signals
  – GPS
  – Maps

Subsystem: Propulsion

- Definition: ? ? ?

- Examples:
  - Propeller
  - Back Wheel of Bike
  - Transmission
  - Gears
  - Jet Engine

Subsystem: Propulsion

- Definition: Provides movement for a vehicle; drives or pushes a vehicle forward

- Examples:
  - Propeller
  - Back Wheel of Bike
  - Transmission
  - Gears
  - Jet Engine

Subsystem: Support

- Definition: ? ? ?

- Examples
  - Roads
  - Street Lights
  - Traffic Signs
  - Helmets
  - Traffic Laws

Subsystem: Support

- Definition: Items aid the transportation system and its function, but are not directly a part of it

- Examples
  - Roads
  - Street Lights
  - Traffic Signs
  - Helmets
  - Traffic Laws

Supplemental Resources 1d

Taking on the role & responsibilities of a transportation engineer!

Are you ready?

1. Which best describes transportation technology?

A. a system that is used to move people and products

B. an enterprise that changes raw materials into goods

C. the building and finishing of structures

D. the conversion of mechanical energy into heat energy

2. Which of the following parts of a car belongs to its control system?

A. fuel tank

B. steering wheel

C. front seat

D. windshield wipers

3. Which of the following is the best example of a part of the propulsion system of a tractor?

A. engine

B. front headlight

C. hood

D. steering wheel

4. A ship has a satellite communication device to identify the ship's position at sea. For which of the following activities is this device most likely used?

A. control

B. propulsion

C. suspension

D. guidance

5. A __________________ is a group of parts that work together to perform a function.

A. suspension

B. system

C. subsystem

D. structure

6. Harry is 16 and just got his license. His parents bought him a new sports car for his birthday. He was driving home from his friend's house in the dark and forgot to put his headlights on. He crashed and totaled his car. Harry did not make use of the _________________________ subsystem.

A. support

B. structure

C. control

D. guidance

7. Harry's parents bought him another car a few weeks later. Harry forgot to use his headlights again, but on his way to the grocery store there were street lights that lit the roads enough for Harry to see in the dark. Harry is thankful for which subsystem?

A. support

B. structure

C. control

D. guidance

8. Many people that travel to places far away choose to travel by airplane. Passengers on planes stay in the cabin, which is part of the ___________________ subsystem.

A. support

B. structure

C. control

D. guidance

9. A bicycle has two wheels touching the road, a unicycle has one wheel touching the road and a tricycle has 3 wheels touching the road. Based on this information, these vehicles differ mainly in their ___________________________ subsystems.

A. propulsion

B. suspension

C. guidance

D. control

10. Which is not a major mode of transportation?

A. Air

B. Land

C. Walk

D. Space

11. A naval engineer focuses on ________________________ transportation.

A. Air

B. Land

C. Space

D. Water