Investigation of the Effectiveness of Graphic Organizers on Science Nonfiction Text Comprehension

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Abstract

The purpose of this study was to determine if using Thinking Maps graphic organizers increased student comprehension of science nonfiction texts. The researcher wanted to further determine how Thinking Maps graphic organizers would help students who were categorized in different ability levels on the Winter 2019 MAP test. Two research questions guided the study: Does the use of Thinking Maps graphic organizers, such as circle maps, multi-flow maps, and tree maps, affect student comprehension of science nonfiction texts? And does the use of Thinking Maps graphic organizers affect the comprehension of students of different reading abilities as determined by the Winter 2019 MAP test scores in both Informational Text and the Vocabulary Acquisition and Use categories? Twenty-eight fifth grade students from one classroom participated in the study with 26 completing the study; two did not complete the study due to absences. All participants increased in comprehension during the study. Of the participants completing the study, 76.92% scored 80% or above on the unit post-test compared to no participants scoring 80% or above on the pre-test.

Keywords: comprehension, Thinking Maps, graphic organizers

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Expository texts pose their own unique sets of challenges for students. At around 4th grade, science texts switch from a narrative style, which tends to focus on a main idea, to an expository style with lots of concepts and unintegrated facts that students must make sense of and organize the information on their own (Roman, Jones, Basaraba, & Hironaka, 2016). "Intermediate and secondary content area curricula include increasingly complex material and abstract concepts that require students to use higher-order processing and comprehension skills" (Dexter, Park, & Hughes, 2011, p. 204). The Common Core State Standards (CCSS) require higher-order thinking skills from students which can be a challenge when they are struggling to make sense of expository texts (Singleton & Filce, 2015). "The expectations are that students will be able to read a text closely and comprehend explicit ideas, identify main ideas and details, and use the structure of informational text to understand how ideas and concepts relate" (Scott & Dreher, 2016, p. 286). As students progress through each grade in school, these skills are designed to build on the skills of the previous year.

Graphic organizers are evidence-based tools that teach inference, visual connections, and provide a framework to extract details (Roman, Jones, Basaraba, & Hironaka, 2016). "They are intended to promote more meaningful learning and facilitate understanding and retention of new material by making abstract concepts more concrete and by connecting new information with prior knowledge" (Dexter, Park, & Hughes, 2011, p. 204). While many graphic organizers help students organize information, few help students to then "follow through with an organized, coherent piece of writing" (Hyerle, 1996, p. 85).

Thinking Maps are eight specific types of graphic organizers in which each map serves a different, specific purpose and aligns with a single thinking process. As students in 5th grade encounter more challenging texts and text structures they are unfamiliar with, Thinking Maps can help students to identify the important information from expository texts and organize the information in a visual format which will help them to make sense of the information in order to help them comprehend the text. By implementing the use of Thinking Maps in my fifth grade classroom, I want to investigate their effectiveness on students' comprehension of science nonfiction text. The purpose of the study is to determine the effect the use of graphic organizers will have on student comprehension of science nonfiction texts.

The study hypothesizes that using Thinking Maps graphic organizers, including circle maps, multi-flow maps, and tree maps will help students determine important information, define keywords, sort and classify information, and determine cause-and-effect which all aid in comprehension. The study hypothesizes that using Thinking Maps graphic organizers will increase the comprehension of lower level, those categorized as Average or High Average, students as categorized by their Winter 2019 MAP test scores more than higher level students, more than students categorized as High ability.

Two research questions guided this study:

- Does the use of Thinking Maps graphic organizers, such as circle maps, multi-flow maps, and tree maps, affect student comprehension of science nonfiction texts?
- Does the use of Thinking Maps graphic organizers affect the comprehension of students of different reading abilities as determined by the Winter 2019 MAP test scores in both Informational Text and the Vocabulary Acquisition and Use categories?

In the following literature review, the researcher defines graphic organizers and discusses comprehension issues students and teachers face in the classroom. The demands of the CCSS and the Next Generation Science Standards (NGSS) are examined. A review of research supports graphic organizers having a positive effect on comprehension when the graphic organizer is taught and used appropriately. Finally, implications for how teachers can implement graphic organizers are outlined.

Graphic Organizers and Text Comprehension

Numerous studies and articles detail the importance of text comprehension for overall student success. "Unfortunately, many students have difficulty recognizing the organization of ideas when attempting to understand the content as they navigate the lengthy passages found in textbooks" (Scott & Dreher, 2016, p. 286). When students struggle with understanding the structure of the text they are reading, making inferences, or connecting information, they may have trouble comprehending the full meaning of what they are reading and learning. Teachers need to be able to help their students who are struggling with text comprehension, especially informative expository text, whether that student is an average student or a student dealing with a learning disability. Many teachers are required to plan their lessons with, and help their students meet, the demands of the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS) which emphasize developing higher-order thinking skills and being able to work with and comprehend complex texts.

This review will look at a specific strategy, using graphic organizers, in order to help students to improve comprehension of expository texts. Challenges facing students with learning disabilities and strategies to specifically help students with learning disabilities through the use of graphic organizers will also be addressed. Graphic organizers are evidence-based tools that teach inference, visual connections, and provide a framework to extract details (Roman, Jones, Basaraba, & Hironaka, 2016). “Graphic representations or organizers have been defined as spatial displays of key ideas from texts arranged to communicate conceptual hierarchy as well as relationships and connections between ideas, facts, and concepts” (Scott & Dreher, 2016, p. 287). “They are intended to promote more meaningful learning and facilitate understanding and retention of new material by making abstract concepts more concrete and by connecting new information with prior knowledge” (Dexter, Park, & Hughes, 2011, p. 204).

Graphic organizers use visual displays that arrange words using boxes, cells, arrows, or other visual cues to depict key concept in a way that students can comprehend (Ciullo, Falcomata, & Vaughn, 2015). Graphic organizers come in many forms and titles, and can be adapted to the need of the individual lesson or task. Some examples include semantic mapping which is used to identify main idea and supporting details, semantic feature analysis which is similar to semantic mapping but presented in a matrix form, and the style most people think of when they think of graphic organizers, the visual display which organizes information in one of five ways; temporal (e.g., timeline), spatial (e.g., decision tree), sequential (e.g., flowchart), hierarchal (e.g., taxonomy), or comparative (e.g., Venn diagram) (Dexter, Park, & Hughes, 2011).

Thinking Maps are eight specific types of graphic organizers which correlate to eight specific thinking processes (Hyerle, 1996). Thinking Maps allow students to brainstorm and organize the information they gather on a specific map for a specific thinking purpose with the goal of then using that information to communicate what they have learned through writing, speaking, or some other presentation. Whereas traditional graphic organizer handouts where students fill in blanks, bubbles, squares, or other predetermined shapes, Thinking Maps are constructed by the student to fit the need of the task and because of that does not limit the student to the number of ideas or pieces of information that can be included on the Thinking Map. The eight Thinking Maps and their purpose are:

Circle map—helps define words or things in context and presents points of view. *Bubble map*—describes emotional, sensory, and logical qualities. *Double bubble map*—compares and contrasts qualities. *Tree map*—shows the relationships between main ideas and supporting details. *Flow map*—shows events as a sequence. *Multi-flow map*—shows causes and effects and helps predict outcomes. *Brace map*—shows physical structures and part-whole relationships. *Bridge map*—helps to transfer or form analogies and metaphors. (Hyerle, 1996, pp. 85-86)

Comprehension Issues Facing Students

All students need instruction and guidance in the skills and strategies needed to improve their text comprehension. “During the third and fourth grade, students mainly read narrative texts. However, after fourth grade, children move beyond narrative text to expository text” (Botsas, 2017, p. 143). At around 4th grade, science texts switch from a narrative style which tends to focus on a main idea to an expository style with lots of concepts and unintegrated facts that students must make sense of and organize the information on their own (Botsas, 2017; Roman, Jones, Basaraba, & Hironaka, 2016). Expository texts pose their own unique sets of challenges for students. “The structure is complex, with many missing cohesive connections and without a continuous flow of information and time sequence, contrary to narrative texts” (Best et al., 2008; Kendeou, Muis, & Fulton, 2011 as cited in Botsas, 2017, p. 141). “Intermediate and secondary content area curricula include increasingly complex material and abstract concepts that require students to use higher-order processing and comprehension skills” (Dexter, Park, & Hughes, 2011, p. 204).

In their study of a sample of science textbooks found in schools, Roman, Jones, Basaraba, and Hironaka (2016) found that many science texts sentence structures were missing logical connections in their writing which demanded readers infer meaning which can be a challenge for many students. Furthermore, “scientific reasoning in the classroom requires students to rely more heavily on inductive and deductive thinking, skills that are often difficult for students” (Dexter, Park, & Hughes, 2011, p. 204). Additionally, social studies texts not only have details students need to remember, but also text components such as compare and contrast, cause and effect, trends, and themes (Roman, Jones, Basaraba, & Hironaka, 2016). As seen in these examples, texts and text structures differ across content areas and students need to be able comprehend text in all disciplines (Fisher & Frey, Engaging the adolescent learner: Text complexity and close reading, 2012). “Furthermore, words used in expository texts are often of high content density, unknown, abstract, and technical” (Botsas, 2017, p. 141). These factors make comprehension a challenge for students.

Comprehension Issues Facing Students with Learning Disabilities

Students with learning disabilities (LD) and/or those in special education (SpEd) programs have additional challenges and needs. Much of the science content being taught uses expository texts which is especially challenging “due to higher expectations for students with learning disabilities studying the general science curriculum, where they have significantly lower performance than their typical classmates” (Scruggs & Mastropieri, 2007, as cited in Botsas, 2017, p. 142) “More than 20% of high school students with LD typically score at least five grade levels below nondisabled students in reading (National Joint Committee for LDs, 2008) and numerous students with LD are unprepared for the rigor of secondary school reading” (Ciullo, Falcomata, & Vaughn, 2015, p. 16). According to data from the National Assessment of

Student Progress, only 11 percent of students with learning disabilities were at or above the proficient level for science in eighth grade and only six percent of twelfth graders with learning disabilities scored at or above the proficient level (Dexter, Park, & Hughes, 2011).

Students with learning disabilities have unique needs and challenges and need to be provided with appropriate skills and strategies to help them comprehend what they are reading and learning so that they can achieve and grow in their education. “Because of differences in the brain that affect how information is received, processed, and expressed, a student with a learning disability will see and hear information differently from other students” (Hughes & Parker-Katz, 2013, p. 94). “Students with learning disabilities face problems in comprehending any kind of text, because of their general inability to understand textual structure and making mental representations” (Botsas, 2017, p. 142). Students with learning disabilities are more likely than their peers to be disengaged from the learning process, have trouble organizing the knowledge they have in meaningful ways, and have difficulties reading and comprehending expository text than narrative text which all leads to less success than their peers (Hughes & Parker-Katz, 2013).

“Many students with learning disabilities (LDs) experience pervasive difficulty with reading for understanding and these challenges often increase after the primary grades due to the shift in reading more complex informational text” (Ciullo, Falcomata, & Vaughn, 2015, p. 15). The shift in text complexity can be difficult for most students, but those difficulties are compounded for students with learning disabilities (Dexter, Park, & Hughes, 2011). Expository textbooks can be a struggle as students need to infer text structure and meaning (Roman, Jones, Basaraba, & Hironaka, 2016). “Because of their poor or fragmented prior knowledge, students with learning disabilities struggle to form a coherent representation of the meaning of a text, often failing to generate the necessary inferences” (Best et al., 2008 as cited in Botsas, 2017, p. 142).

Students with learning disabilities struggle with disciplinary text literacy, complex texts, and the decrease in direct instruction from the teacher as they go through school and transition to secondary school (Singleton & Filce, 2015). Students with learning disabilities have challenges with comprehension components such as fact recall, summarization, locating pertinent details to support main ideas, sequencing and inference style questions which are needed to understand expository texts as well as to meet the cognitive demands of the CCSS (Ciullo, Falcomata, & Vaughn, 2015). “The difficulty of children with learning disabilities to comprehend expository texts is associated with conceptual density, less familiar concepts and difficult and technical vocabulary” (Botsas, 2017, p. 142). Students with LD or in SpEd programs can have difficulty with these higher-order thinking skills.

Implication of Common Core State Standards and Next Generation Science Standards

Most school districts work under the (CCSS) and the (NGSS) which aim to guide students into deeper learning and preparedness for college and beyond (Common Core State Standards Initiative, 2018). Teachers and students both feel the impact of these standards as:

One goal of the CCSS is to ensure that students gain adequate exposure to a range of texts and tasks. Increasing with each grade level is an emphasis on information text so that students build background knowledge, vocabulary, and understanding. In addition, students advancing through the grades are expected to meet each year’s grade-specific standards and retain or further develop skills and understandings mastered in preceding grades to demonstrate college readiness and high cognitive demand. (Ciullo, Falcomata, & Vaughn, 2015, pp. 23-24)

The CCSS require higher-order thinking skills from students which can be a challenge when they are struggling to make sense of expository texts (Singleton & Filce, 2015). “The expectations are that students will be able to read a text closely and comprehend explicit ideas, identify main ideas and details, and use the structure of informational text to understand how ideas and concepts relate" (Scott & Dreher, 2016, p. 286). As students progress through each grade in school, these skills are designed to build on the skills of the previous year.

The CCSS stress the importance of academic and discipline-specific literacy and the ability to comprehend complex text (Davis, & Wanzek, Hall, Kent, McCulley, 2013; Fisher & Frey, 2012). The CCSS and the NGSS also aim for students to be able to make text-based arguments which require students to be able to comprehend the text then synthesize the information found (Roman, Jones, Basaraba, & Hironaka, 2016). The Common Core State Standards accentuates the importance of proficiency with informational and content-area text to a greater extent than many upper elementary educators may be accustomed to (Ciullo, Falcomata, & Vaughn, 2015).

Results of Graphic Organizer Research

Studies show that students' comprehension increases in general, and specifically with expository texts, when they use graphic organizers. A study was conducted with students in grades 4 to 6 in which one group used graphic organizers to study social studies texts while the other group studied from the text only (Ciullo, Falcomata, & Vaughn, 2015). The study found that students who used graphic organizers significantly outperformed the group who did not use the graphic organizers on a researcher-developed measure. Graphic organizers reduce the cognitive demand on students, reduce their anxiety, and provide a visual representation of the information they are reading (Singleton & Filce, 2015).

"Research indicates that understanding text organization and engaging in generative activities such as graphic displays of content appear to promote comprehension of expository text" (Scott & Dreher, 2016, p. 293). Robinson, Odom, Hsieh, Vanderveen, and Katayama (2006) found that graphic notetaking was more beneficial for comprehension than traditional linear notetaking and partial graphic organizers, where students fill in information to complete the notes, produced the best results on tests for comprehension. Using semantic mapping graphic organizers increased student vocabulary comprehension more than traditional vocabulary instruction techniques (Ciullo, Falcomata, & Vaughn, 2015).

In making abstract information concrete by using pictures, graphic organizers help students read for meaning and students can better understand relationships between concepts across subject areas (Hall, Kent, McCulley, Davis, & Wanzek, 2013; Scott & Dreher, 2016). "Graphic organizers can be implemented during reading to emphasize key information, or subsequent to reading as a study guide for content knowledge" (Ciullo, Falcomata, & Vaughn, 2015, p. 16). Graphic organizers can be used to teach text structure using visual representations. Graphic organizers "spatially group and connect concepts so readers are more likely to perceive them as being interrelated and to draw perceptual inferences about their relationships" (Dexter, Park, & Hughes, 2011, p. 205).

Second-grade students who received text structure instruction as they read science texts were better able to complete a written summary of content and gained as much content knowledge as the students in the content groups who did not receive the text structure instruction. Slater, Graves, and Pichè (1985) documented that ninth-graders' recall was enhanced if they were instructed to pay attention to text organization and to use a structured representation as they read a passage. Similarly, Meyer and Poon (2001) found that adults trained to identify text structures recalled more than those in comparison groups and were more successful in identifying the gist or main ideas. (as cited in Scott & Dreher, 2016, p. 289)

Contrasting to what much research says, Scott and Dreher found the act of students independently choosing and then constructing their own graphic organizers appears to place considerable demands on the working memory which may impact the degree to which students are able to focus on the content itself (2016). "Stull and Mayer (2007) found that research-generated graphic organizers (as opposed to student generated) resulted in statistically significant gains in content acquisition in typically achieving students" (as cited in Ciullo, Falcomata, & Vaughn, 2015, p. 23). This may be the situation when students are not taught, and have not practiced, the direct connection of text structure to different types of graphic organizers. Students not trained in the proper way to use and adapt graphic organizers can see them "as a fixed entity, not a tool that is modified and adjusted to display the structure of the information it contains" (Scott & Dreher, 2016, p. 309) and additionally may become more focused on physically completing the graphic organizer as the goal instead of analyzing and representing the information from the textbook. The Thinking Maps program and the administration and staff implementing them recognize that "it is critical that teachers be trained 'to introduce and model for students how to transfer the maps across content areas,' so that students can consciously use them, both independently and in cooperative groups" (Hyerle, 1996, p. 88).

Although much research exists on the benefits of using graphic organizers, they are not always implemented correctly. When graphic organizers are used before learning takes place, students are not using graphic organizers as a tool to organize what they have learned; instead, students are simply filling in information that may not have much meaning to them (Fisher & Frey, 2018). Graphic organizers need to be used purposefully in order for them to truly facilitate learning. Another misuse of graphic organizers is when the graphic organizer is seen as the final step in learning instead of a tool to aid learning with a piece of writing or a discussion as the final product (Fisher & Frey, 2012). The developers of Thinking Maps also recognized that too often graphic organizers were seen as the final product and students did not know what to do with the information on their graphic organizers (Hyerle, 1996). When used as a tool to connect content to the learning purpose, teachers found that Thinking Maps "had successfully helped students develop their thinking processes and their ability to organize ideas, improved the quality and quantity of their writing, and also motivated them to learn" (Hyerle, 1996, p. 88).

Results of Graphic Organizer Research for Students with Learning Disabilities

A study found that using graphic organizers improved comprehension for all students, but students with learning disabilities showed the most gains (Mahdavi & Tensefeldt, 2013). Furthermore, Hall, Kent, McCulley, Davis, and Wanzek (2013) found that students with learning disabilities found graphic organizers especially helpful with comprehension of social studies texts. In a study conducted with seven middle school students who were identified as learning disabled, the researchers conducted a baseline test for comprehension then used graphic organizers as intervention with social studies texts. After using graphic organizers, the percentage of mean increase ranged from 51 percent to 131 percent for each student (Ciullo, Falcomata, & Vaughn, 2015). Graphic organizers worked well for all seven of the students with learning disabilities. "Having students with LD use an array of graphic organizers is yet another strategy that builds on the visual elements key to organizing information and useful for a wide range of learners" (Hughes & Parker-Katz, 2013, p. 100).

Meta-analysis of the use of graphic organizers with intermediate and secondary students with learning disabilities on student comprehension indicates that graphic organizers improve the factual comprehension and vocabulary knowledge in science not only for the immediate posttest, but the students also remembered the contents for longer periods of time than students who did not use graphic organizers (Dexter, Park, & Hughes, 2011). The study further revealed that, due to the nature of the science material covered which called for inductive thinking and inference from students with learning disabilities, the positive results suggest that graphic organizers are effective not only improving basic skills (e.g., factual recall), but also for improving higher level skills (e.g., inference) (Dexter, Park, & Hughes, 2011). The ability to successfully use and improve the higher level thinking skills are especially important for success under the CCSS.

Implications for Teachers

Teachers can appropriately implement the use of graphic organizers in their classroom to help with comprehension. "As educators help students recognize that graphic representations display how ideas are organized and related, they will be helping student gain a deeper understanding of the domain content they are trying to teach" (Scott & Dreher, 2016, p. 311). The goal of strategy instruction, such as seen when using graphic organizers, is to help students develop self-monitoring and self-regulation abilities to support comprehension and, for students with learning disabilities, strategy instruction can help students begin to discriminate between crucial and less important material and to start to summarize text (Hughes & Parker-Katz, 2013). Teachers have a vital role in appropriately implementing the use of graphic organizers in the classroom:

> To establish relationships between concepts, the teacher explains, models, or demonstrates the use of specific generative activities and has students apply them to the content being learned. Wittrock recommended teaching text organization and displaying that organization (e.g., graphic representations) as a way to develop an understanding of relationships between concepts in text which would facilitate comprehension. (Scott & Dreher, 2016, p. 291)

In order for graphic organizers to truly be helpful for students, teachers must model how to use each type of graphic organizers they use and then scaffold the learning so that eventually students can create and effectively use their own graphic organizers as they read expository texts

(Dexter, Park, & Hughes, 2011; Fisher & Frey, Engaging the adolescent learner: Text complexity and close reading, 2012; Hughes & Parker-Katz, 2013; Scott & Dreher, 2016). Teachers need to help students understand how graphic organizers show "the organization of ideas and the relationship between concepts in the textbook content they are studying. It is this understanding that makes graphic representations such a potentially valuable teaching tool" (Scott & Dreher, 2016, p. 288). Teachers should allow students time to learn the content needed in order to successfully use graphic organizers as learning tools instead of busy work (Fisher & Frey, The uses and misuses of graphic organizers in content are learning, 2018).

When teachers are able to help students see how different graphic organizers relate to the text they are reading and the purpose of different types of graphic organizers, students will then be able to independently choose appropriate types of graphic organizers to use with future texts they read, even if that text is in a different content area (Scott & Dreher, 2016). Scott and Dreher's research showed that when students were not taught the connection between text structure and different types of graphic organizers, students would choose a graphic organizer they were familiar with and mold the information they read to fit the graphic organizer instead of finding an appropriate graphic organizer to effectively represent the important information from their reading (2016). When teachers are teaching students with learning disabilities, this instruction needs to be very explicit to help guide students to finding the important information and to make connections between concepts (Dexter, Park, & Hughes, 2011).

As teachers learn about the needs of their students, they can accurately match expository texts that students can best use and choose appropriate graphic organizers for each lesson to aid in comprehension. There are many types of graphic organizers available, or teachers can easily make their own to fit their needs, that can provide benefit at all stages, pre-, during, and post-reading (Singleton & Filce, 2015). Teachers also need to understand that "students may need time to become proficient in graphic representation construction in order to reduce the demands it places on working memory" (Scott & Dreher, 2016, p. 309) so they should plan the time needed for instruction and practice needed for students to become proficient in the skill. As students become familiar with different graphic organizers, text structures, and learning goals, the students should be allowed to pick the type of graphic organizers that fits their needs (Fisher & Frey, The uses and misuses of graphic organizers in content are learning, 2018).

Teachers of 4th and 5th grade students have a special task ahead of them preparing their students for the shift from elementary work and text structures, which tends to be more narrative in style, to middle school work and text structures which tend to be more expository in style. As education shifts and 4th and 5th grades are more often teaching informational-text reading, more research needs to be done with students struggling with comprehension students with learning disabilities in elementary and upper elementary grades as little research exists (Ciullo, Falcomata, & Vaughn, 2015). "Approximately 54 percent of all special education students spend at least 80 percent of their day in general education classrooms" (Hughes & Parker-Katz, 2013, p. 93). General education teachers need support to help students with learning disabilities find success in the general education classroom setting.

In Scott and Dreher's research, in the schools they worked in, they found that even though the use of graphic organizers was mandated by the district, the teachers had not been properly or adequately trained in how graphic organizers should be used to assist in student learning (2016). This seems to imply that although districts may see the importance and relevance of the use of graphic organizers in the classroom, they are not equipping their teachers with professional development or training to use graphic organizers in a way that truly helps students to learn and comprehend what they are reading.

"Many general education teachers report that their preparation seems inadequate to work with students who are struggling academically (McHatton and McCray, 2007) and that they do not know how to help students develop strategies necessary for reading comprehension" (Hughes & Parker-Katz, 2013, p. 93). These studies suggest that teachers need to be provided with quality professional development and instruction on how to properly implement graphic organizers so that students are able to identify text structures and match the learning goal to the type of graphic organizer that will most accurately display important information. Graphic organizers are not as effective if teachers are not able to help students make that connection.

Implications for Future Research

Students of all ages can benefit from comprehension instruction with graphic organizers. Current research largely focuses on students in middle school and high school. "This grade range was selected because it is typically when curriculum become more complex and students are required to learn primarily through didactic lecture and expository text presentation" (Dexter, Park, & Hughes, 2011, p. 206). Further research should be done with children in both lower and upper elementary grades, focusing on comprehension issues and instruction as well as the use of graphic organizers to aid comprehension instruction. Many studies are outdated, so future research is suggested to update data using current classroom conditions, populations, and materials (Dexter, Park, & Hughes, 2011). Many studies with graphic organizers and students with learning disabilities take place with instruction in self-contained situations only, so different studies in different educational settings is suggested.

Methods

This study will utilize a quantitative approach and quasi-experimental design. It will consist of one group of participants. The study will be centered around a science unit on Forces and Motion (FAM). There will be a pre- and post-test before and after the FAM science unit content with formative assessments within the study to check for understanding and growth in comprehension of the science content and knowledge of the use of the graphic organizers throughout the intervention. The participants of the study will learn how to use Thinking Maps graphic organizers to help increase their comprehension of the science nonfiction texts. Participants have been introduced to Thinking Maps, Full Option Science System (FOSS) hands-on labs and activities, and the 5th grade Scott Foresman *Science* textbook before the study.

Participants and Setting

The participants in this study will be purposely selected from the teacher researcher's fifth grade gifted science class in Northern Illinois. The sample will be male and female participants ranging in age from 10-11 years old. Twenty-eight participants will take part in the study. There are 11 girls and 17 boys. Seventeen participants were Caucasian, 1 was Hispanic, 3 were Asian, 5 were Middle Eastern, and 2 were Eastern European. 1 participant has type 1 diabetes and has an insulin pump. This participant needs to see the nurse multiple times per day as needed to address blood sugar levels. That same participant also has ADHD Non-attentive Type and a 504 for the ADHD and diabetes. One male participant is in the English Language Learner (ELL) program through the school district but the parents have declined services for him. He speaks English well and seems to communicate well with others when speaking in English and has fairly good comprehension of texts written in English. Participants range in socioeconomic status and reading ability. See Table 1 below for participant academic designations.

Table 1

Number of Participants according to Designation and Category of Reading. n=28

Designation	Average	High-Average	High	Total
Informational Text	2	8	18	28
Vocabulary Acquisition and Use	0	7	21	28

Note: Designations are based off Winter 2019 MAP scores

The location of this study will be in a fifth grade classroom in an all gifted fifth through eighth grade middle school in Northern Illinois. The school is located in a large, suburban city with a population of over 150,000. The participants in the study are part of the city's public school gifted program in which participants from all over the district test in to the program using either the Naglieri Nonverbal Ability Test or the CogAT Cognitive Abilities Test. Participants need to score in the 95th percentile or above in one area on either test to qualify for the gifted program. The elementary and middle school campus consists of two buildings; elementary first through fourth in one building and elementary fifth and middle school sixth through eighth in a second building.

According to the 2017 Illinois Report Card, the school's student population of 457 students is 63.7% White, 5.5% Black, 17.7% Asian, 8.5% Hispanic, and 4.6% Two or More Races (Illinois State Board of Education, 2018). The school consists of 54% female students and 46% male students. 14% of students are low-income and 2.2% of students have an IEP (Illinois State Board of Education, 2018). The current fifth grade has four sections of students with 28 students in each section. Each section has one teacher. Two teachers teach social studies (SS) and English language arts (ELA) while the other two teach math and science. A SS/ELA teacher partners with one of the math/science teachers to switch classes half way through the day. The participating class will be the math and science teacher researcher's homeroom classroom.

Data Source and Research Materials

Data for this study was collected using a pre-test before the unit of study and a post-test after completion of the unit, both administered as a Google Form test. The unit on Forces and Motion is broken up into four sections, *Air Trolley, Speed, Newton's Laws, and Simple Machines*. Each section took between four to eight school days to complete. At the end of each section participants were given a paper and pencil quiz covering the content from the textbook and the lab experiments from that section. Tests and quizzes will cover vocabulary definitions and scientific symbols and will include short answer and extended responses. The scores for all tests and quizzes were recorded at the time of completion. All tests and quizzes were developed and created by the teacher researcher. Definitions, concepts, and sample questions were drawn from both the Scott Foresman *Science* textbook and the FOSS Forces and Motion unit.

Because of school district snow days, the study began two days later than originally planned. Additionally, after the study began, the teacher researcher was notified they would need to miss a day of school during the time of the study to attend a math conference. On that day, a substitute taught the class and the study was put on hold for that day as to ensure the teacher/researcher was the only person instructing the class in order to ensure the accuracy and integrity of the study. For each day missed because of snow days or teacher absence, the teacher/researcher was able to extend the study in order to complete all lessons following the order of the original timeline.

Procedures of Data Collection

Section One: Air Trolley

The first section of the Forces and Motion unit lasted seven school days which satisfied days one through seven of the study unit. On the first day of the study and this section of the *Forces and Motion* unit, participants took a Google Forms *Forces and Motion Unit Pre-Test* (Appendix D) online. The pre-test consists of multiple choice questions and short answer questions to establish a baseline of what participants know about forces and motion. The items and concepts on the tests and quizzes in this unit come from the Scott Foresman *Science* textbook and the FOSS *Forces and Motion* unit.

After the pre-test on the first day, participants began taking notes from their Scott Foresman *Science* textbook in chapter thirteen, lesson one *How can you describe motion?* Participants took traditional Cornell style notes and were told to focus on vocabulary and scientific symbols and formulas. In the first section of the study the participants did not use any Thinking Maps as a control section to compare future sections to.

Participants then spent the next four school days, days two to five of the study, with the FOSS hands-on lab *Air-Trolley* constructing, engineering, and testing their air-trolleys to measure distance (Appendix E). On the first of those days, the participants constructed the trolley and experimented with it moving to get familiar with the air trolley. On the second day participants spent the whole class time working with their air-trolleys and paying attention to winding the propeller and the distance traveled.

During the class period on the third day the participant groups were assigned a certain number of winds of the propeller and conducted five trials with their number of winds then recorded the data in a table on the *Air-Trolley Distance Graph* worksheet (Appendix F) and found the average distance for a specified number of winds of the propeller. On the fourth day the class compiled their data in the table at the top of the Air-Trolley Distance graph and then graphed the class results on the bottom graph. Participants were to look for relationships between the number of winds and the distance.

Before working with the air trolleys participants discussed the terms and symbols for initial position x_i, final position x_f, distance *d*, the distance formula $d = x_f - x_i$, the delta Δ for change, independent variable, dependent variable, and x- and y-axis. Participants took notes in their science notebooks but did not use any Thinking Maps.

On the sixth day of the section, the participants completed a two-sided *Road Races* worksheet (Appendix G) in which they used their working knowledge of distance and the notes they took in order to calculate and compare the distances of different vehicles. On the seventh day of the study, and the final day of the Air-Trolley section, the participants took a paper-and-pencil *Forces and Motion Quiz 1: Air Trolleys* (Appendix H) on the content, vocabulary, symbols, and formulas covered in the first section. As participants finished their quiz they read their Scott Foresman *Science* textbook in chapter thirteen, lesson two *What are forces?* in preparation for the next section.

Section Two: Speed

The second section of the study, *Speed*, lasted nine school days and satisfied days eight through seventeen of the study. This section was originally planned to last eight days, but as participants were working collaboratively on their Thinking Maps Circle Maps (Appendix I) in the beginning, they needed an extra class period in order to complete their maps. The second section began with participants working in small groups and taking notes on the next lesson in the Scott Foresman *Science* textbook in chapter thirteen, lesson two titled *"What are forces?"*

and using Circle Maps to brainstorm and define the different types of forces. Participants were also allowed to access the internet for further details on their force. Each group was assigned one of the following types of forces in the lesson, pushes and pulls, gravity, magnetism, electricity, and friction.

The groups spent the first three days of the section taking notes and developing their Circle Maps. The purpose of a Circle Map is to brainstorm about the topic. Items included in the circle map could be anything the creator feels is relevant to the topic including, but not limited to, definitions, examples, pictures of or related to the topic, qualities, and descriptions. The purpose of the Circle Map is simply to get all ideas into one place. As participants worked further with Circle Maps, they color coded their ideas in the circle map by different themes, such as all definitions being circled or highlighted in one color, qualities in another, etc. From there, participants can take the information from their Circle Map and use it on another type of map to further organize the information, to produce a piece of writing, or to present the information in an organized and clear way.

On the fourth day of the *Speed* section, the groups presented their Circle Maps to the entire class. Using the information from the Circle Maps, the participants then created a Thinking Maps Tree Map (Appendix J) to classify the different types of forces. The purpose of a Tree Map is to classify information or identify main idea and supporting details. The title of the Tree Map will be *Forces* and each of the branches will be the different forces from the science lesson. Under each type of force the participants organized the important information from the Circle Map about that force. This allowed participants to visually organize their information in order to make connections and deepen comprehension.

The participants used the different Thinking Maps to write two paragraph, as homework, defining and describing any two of the forces discussed in class, but they were not allowed to write about the force they were originally assigned. Communicating, in this case through writing, based off the information on the Thinking Maps is a key difference between Thinking Maps and many other types of graphic organizers. Being able to use the information they placed on the different Thinking Maps to produce thoughtful, organized writing shows that participants have truly comprehended the information.

Communicating based on the Thinking Maps additionally helps participants make the connection between the purpose of the text and the format of how the participant communicates the information. In this case, the Tree Map organized the information into main idea and details and so the writing should reflect that pattern. Participants should write about their forces with the name as a main idea and then give details and examples.

The participants then spent the next five days, days five through nine of the *Speed* section, working with the FOSS activities and hands-on labs to calculate speed and to learn about the forces acting on objects in motion. One day was spent on the *Who Got There First* activity in which participants used the formula for speed to calculate and compare the speed of different vehicles. The teacher-researcher did the first worksheet, *Who Got There First 1* (Appendix K) as a SmartBoard activity and the class and the teacher/researcher calculated the speeds together to model calculating speed accurately. The participants then could choose to work with a partner or independently on the double-sided *Who Got There First 2 & 3* worksheet (Appendix L). This worksheet was homework and used as a quick check on how participants were comprehending speed. On the second day of the FOSS activities, the participants used their knowledge of calculating speed from the *Who Got There First* activities to continue calculating speed and how far a vehicle will travel with the *Time Travel A* and *B* double-sided worksheet (Appendix M).

Participants then spent the next three days in assigned small groups conducting the hands-on lab activity *Speeding Down Slopes* in which they explored the concept of speed, how to calculate speed, and how to solve speed problems. For the first two of those days, participants used a 200cm board which is raised on one end to various elevations, creating various inclines, to calculate the speed of a toy car traveling down the board. Participants discussed the different forces acting on the cars as they traveled down the board. Groups recorded their data on the *Speeding Down Slopes* worksheet (Appendix N). On the third day participants and groups came together to find a class average for the speed of the vehicles at different elevations and graphed the results on the *Speeding Down Slopes* worksheet.

The last day of the unit the participants took the FAM quiz two on the content, vocabulary, symbols, and formulas covered in the second section (Appendix N). One question on the quiz was changed from the proposed quiz from “What factors determine gravity?” to “What is speed?” to better reflect the content and purpose of this unit. This quiz’s results reflected what students learned using Thinking Maps as tools to aid comprehension and what they learned in the Speed lab.

Section Three: Newton’s Laws of Motion

The third section of the study, titled *Newton’s Laws of Motion*, lasted four school days and satisfied days eighteen through twenty-one of the study. This section was originally planned to take five days, but the teacher/researcher discovered that participants needed an extra day to work in the different Thinking Maps thoroughly so the study was extended an extra day. Additionally, an activity was planned that went along with the unit, but due to snow days, teacher-researcher absence, and an unplanned guest speaker, the activity did not fit into the time frame of the study. The other 5th grade teacher did not do this activity either.

In this section participants Focused on Isaac Newton's three laws of motion and continued to learn about the forces studied previously in the unit. Participants began this unit working in the Scott Foresman *Science* textbook using Thinking Maps as tools to aid comprehension and then conducted a FOSS activity. As homework the night before the third section began, participants were assigned to read the Scott Foresman *Science* chapter 13, lesson three titled *What are Newton's Laws of Motion?* in order to be prepared to start working on the first day of section three.

Because participants had already read the lesson and received instruction on the Circle Maps in the previous section, participants spent the first day of this section working in a small group to create a Circle Map to brainstorm and define one of the following; net forces, equilibrium, inertia, or acceleration. The teacher-researcher reviewed Circle Maps briefly before participants began working, but participants spent most of the class period working directly with their Circle Map. Because of the size of the class, multiple small groups were working on each of the different forces separately, and then they combined their information into one Circle Map on their force. As discussed in the previous section, Circle Maps allowed participants to brainstorm and visually organize their thoughts in one place.

On the second day of the section, groups shared their Circle Maps with the class. The other participants recreated the Circle Maps in their notebooks so that they would have information on all of the forces. Participants used the Circle Maps to write a paragraph describing all of the forces discussed in class. Participants began working on the paragraph in class and finished the paragraph as homework.

On the third day of the section the class collaboratively created a Tree Map on Newton's three laws of motion on the SmartBoard. The title of the map was *Newton's 3 Laws of Motion* with each of the laws as its own branch. Below each branch, participants added details including definitions and examples. The Tree Map the class created can be seen in Appendix **. As the Tree Map was created, participants recreated the map into their notebooks. Participants used the information from the Tree Map to write an extended paragraph defining and describing Newton's three laws of motion. Participants were able to start the paragraph in class and finished as homework.

On the last day of the section the participants took the FAM quiz 3 *Newton's Laws of Motion* (Appendix P). The quiz focused on vocabulary and identifying each of Newton's three laws of motion based off of definitions and examples. This quiz was the second quiz given with which participants used Thinking Maps during the section.

Section Four: Simple Machines

The fourth and final section of the study, titled *Simple Machines*, lasted four school days and satisfied days twenty-two through twenty-five of the *Forces and Motion* study unit. For this unit participants worked out of the Scott Foresman *Science* text and used Thinking Maps as comprehension tools. As homework the night before the section began, participants read chapter 13, lesson four *What are simple machines?* from the Scott Foresman *Science* text. In their notes they made a circle map for each type of simple machine so they would be prepared for the in-class activity.

On the first two days of the section, participants worked in small groups to create a Multi-flow Map (Appendix Q) about one of the following simple machines in the lesson; pulley, wheel and axle, lever, or inclined plane. There were eight small groups so two groups each made a

Multi-flow Map about their assigned simple machine. Participants focused on descriptions, examples, and how the simple machine makes life easier. On the third day, participant groups shared their Multi-flow Maps with the class. Participants recreated the maps in their notebooks as they watched other groups present their Multi-Flow Map.

Initially a FAM Quiz 4: Simple Machines written response was planned as the final quiz. While participants still completed this as part of the unit assessment, the teacher-researcher found that the written response was too subjective in grading and different in format in order to accurately compare it to previous quizzes, thus the FAM Quiz 4 scores will not be included in the study data. At the end of the unit, participants took a Google Forms *Forces and Motion Unit Post-Test* (Appendix R) which mirrored the pre-test in format and content.

Data Analysis and Results

Data was analyzed quantitatively using descriptive analysis. The researcher collected pre- and post-test on the Forces and Motion unit along with three section quizzes throughout the unit. The first section of the unit was conducted without the use of graphic organizers or Thinking Maps. The rest of the sections of the unit were completed with the use of Thinking Maps. Participants 3 and 28 were absent the last week of the study and missed a lot of instruction as well as the final unit test, so their data is excluded from the study leaving a total of 26 participants included in the study.

Data Analysis

The researcher used descriptive analysis to quantitatively analyze the data. At the beginning of the unit the researcher administered a Google Forms pre-test electronically. The unit was split into four sections and at the conclusion of each of the first three sections the researcher administered a Forces and Motion quiz. All of the data from the tests and quizzes was organized into data tables and graphs.

The first research question addressed overall comprehension growth as measured by a pre- and post-test. The first table shows all of the scores for each participant as the percentage correct on the pre-test, quizzes, and post-test and includes the percentage correct increase from the pre-test to the post-test. The second figure is a bar graph the shows each participant's pre-test score and post-test score in order to see individual participant growth. The third figure is a histogram of the frequency of the raw test scores on the pre-test and the post-test to display the increase in test scores. In order to look closer at the quiz scores, figure four shows the scores for each participant broken down by percent correct on each quiz.

The second research question addressed whether students of different reading abilities according to Winter 2019 MAP test scores would show differences in comprehension when using Thinking Maps. To address this, the researcher created two tables, one for Informational Text and the second for Vocabulary Acquisition and Use. For each table, the participants are categorized by their MAP results as Average, High Average, or High. On the Vocabulary table, no participants were categorized as Average on the MAP test; all participants were either High Average or High.

Results

Table 2 shows the participant scores for the unit. The pre-test percentage score mean was 47.308% and the post-test percentage score mean was 75.692%. The lowest pre-test score was participant 16 with a score of 3 and a percentage score of 21%. Participant 16 was categorized as Average in Informational Text and High Average in Vocabulary Acquisition and Use. The highest pre-test score was participant 26 with a score of 11 and a percentage score of 79%.

Participant 26 was categorized as High in both Informational Text and Vocabulary Acquisition and Use. The lowest post-test score was participant 27 with a raw score of 6 and a percentage score of 43%. Participant 26 had only one point more than the lowest pre-test score with a score of 4 on the pre-test. Participant 26 was a High Average in Informational Text and High in Vocabulary Acquisition and Use.

Participants 1, 14, 18, and 19 all scored 14 points with 100% correct on the post-test. Participant one made the biggest growth of the four top participants with a raw score growth of nine points from a pre-test raw score of 5 and percentage score of 36% to a post-test score of 14 points and 100%. Participant 1 was High Average in both Informational Text and Vocabulary Acquisition and Use.

Table 2

Participant scores in percent correct (n=26)

n	Unit Pre-Test		Quiz 1 No Thinking Maps TM)	Quiz 2 With TM	Quiz 3 With TM	Unit Post-Test		Points Increase Pre- to Post-test	
	x=	%	%	%	%	x=	%	x=	%
1	5	36	93	70	92	14	100	9	64
2	5	36	80	70	83	10	71	5	35
4	7	50	20	100	83	13	93	6	43
5	5	36	87	80	67	12	86	7	50
6	9	64	67	100	83	11	79	2	15
7	7	50	87	40	N/A*	8	57	1	7
8	8	57	73	100	100	10	71	2	14
9	7	50	93	100	100	10	71	3	21
10	6	43	100	100	83	9	64	3	21
11	4	29	93	90	83	10	71	6	42
12	4	29	20	40	67	10	71	6	42
13	6	43	93	70	100	9	64	3	21
14	10	71	100	100	100	14	100	4	29
15	9	64	100	80	100	9.5	68	0.5	4
16	3	21	73	90	42	9	64	6	43
17	35	36	87	100	58	9	64	4	28
18	8	57	100	100	100	14	100	6	43
19	7	50	87	70	100	14	100	7	50
20	8	57	87	100	100	10	71	2	14
21	7	50	87	100	100	10	71	3	21
22	8	57	80	100	92	10	71	2	14
23	6	43	87	50	83	13	93	7	50
24	7	50	93	80	100	9	64	2	14
25	6	43	73	60	92	10.5	75	4.5	32
26	11	79	100	100	100	12	86	1	7
27	4	29	73	90	58	6	43	2	14
Mean	6.615	47.308	82.038	83.846	86.64	10.615	75.692	4	28.385
SD	1.91					2.06		2.93	

Note. * Participant was absent and did not take the quiz

Overall, as seen in Figure 1, results from the unit pre- and post-tests revealed that all participants grew in comprehension as shown by test scores. The pre-test raw score mean was 6.6 with a standard deviation of 1.91. The post-test raw score mean was 10.6 with a standard deviation of 2.06. Participants made a raw score mean gain of 4 points from the pre-test to the post-test on the Forces and Motion unit.

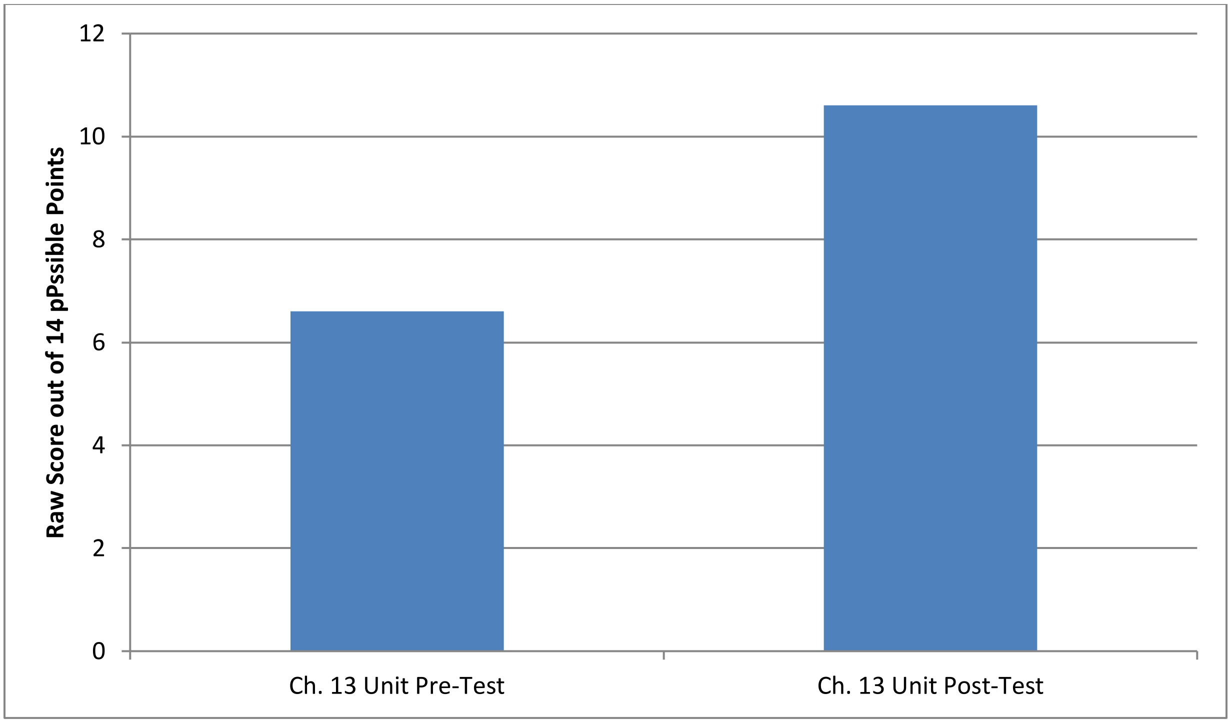

Figure 1. Participant Group Mean Score for Pre- and Post-tests (n=26)

Figure 2 is a histogram in bar graph form showing the frequency of the raw scores on both the unit pre-test, in blue, and the unit post-test, in red. The lowest pre-test score was 3 points and the highest pre-test score was 11 points out of 14 possible points. The lowest post-test score was 6 points and the highest post-test score was 14 points out of 14 possible points. For both tests the scores of the same 26 participants were included.

On the pre-test, 12 of the 26 participants scored below 50% while 6 scored exactly 50% and 8 participants scored above 50%. Two of the participants scored above 70% on the pre-test, but no participants scored 80% or above. On the post-test, only 1 participant scored below 50%, no participants scored exactly 50%, and the rest scored above 50%. On the post-test 10 participants scored 70-79%, 2 scored 80-89%, 2 scored 90-99%, and 4 participants scored 100%.

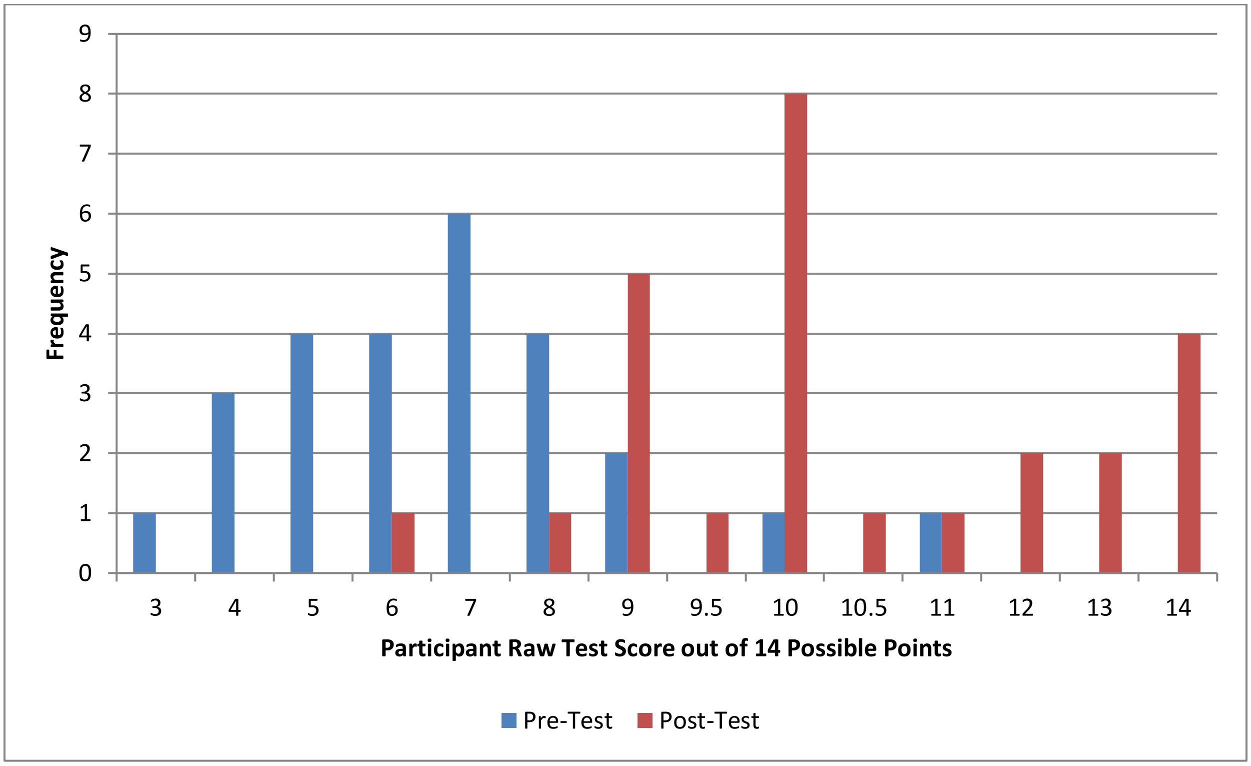

Figure 2. Frequency of Participant Raw Scores (n=26)

Figure 3 shows participants' individual pre-test and post-test raw scores. The blue was where the participant started and the red is where they finished the unit. The participant with the largest overall growth was participant 1 as previously discussed. The participant with the smallest growth was participant 15 with a pre-test raw score of 9 and percentage score of 64% and a post-test raw score of 9.5 and percentage score of 68%. Participant 15 only grew 0.5 raw points and 4% from pre- to post-test.

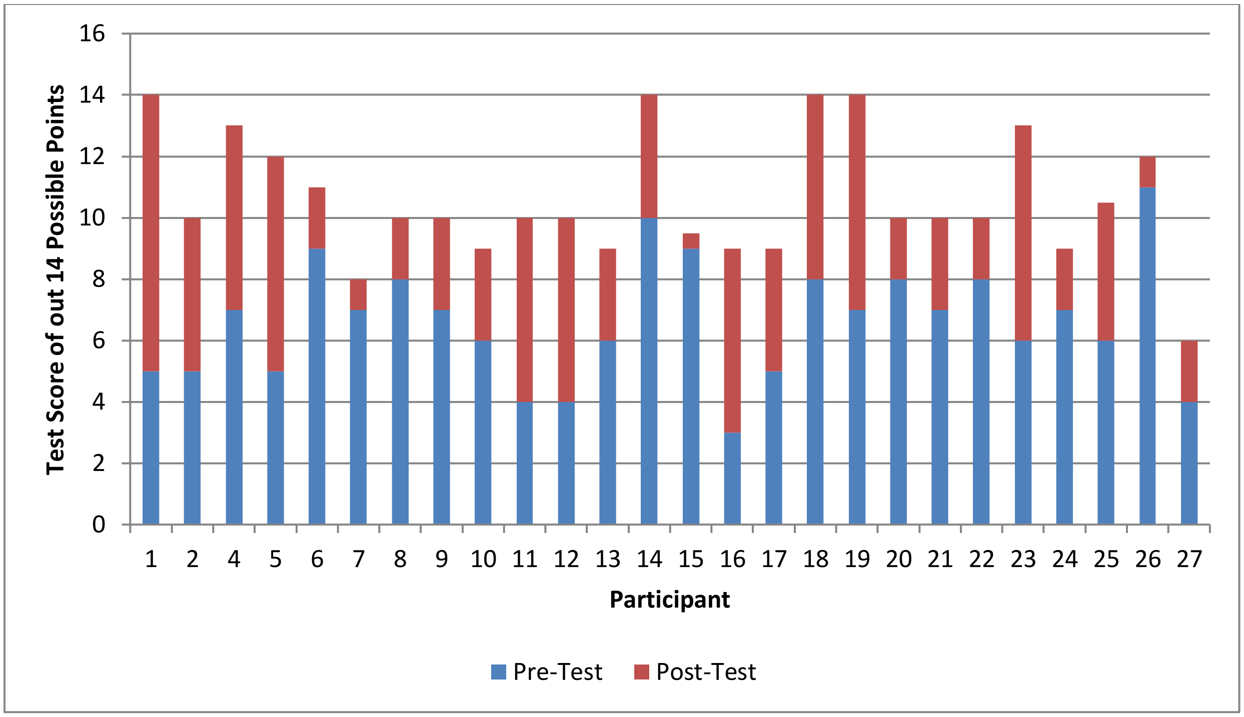

Figure 3. Individual participant unit Pre- and Post-Test Raw Scores (n=26)

Figure 4 shows individual participants' percentage scores on all three of the Forces and Motion (FAM) quizzes. The first quiz from section one used no Thinking Maps graphic organizers. The proceeding sections used Thinking Maps graphic organizers. The mean percentage score for FAM Quiz 1 was 82%. The mean percentage score for FAM Quiz 2 was 83.8% and the mean percentage score for FAM Quiz 3 was 86.6%. The increase from Quiz 1 to Quiz 2 was 1.8% and from Quiz 2 to Quiz 3 was 2.8%. The total increase from Quiz 1 to Quiz 3 was 4.6%. On Quiz 1, only 5 participants got a score of 100% and 18 of the 26 participants scored at or above 80%. On Quiz 2, 12 of the 26 participants got 100% and again 18 participants scored at or above 80%. On Quiz 3, 1 participant did not take the quiz due to an absence. Of the 25 scores recorded, 11 participants scored 100% but 20 of the 25 participants scored at or above 80%.

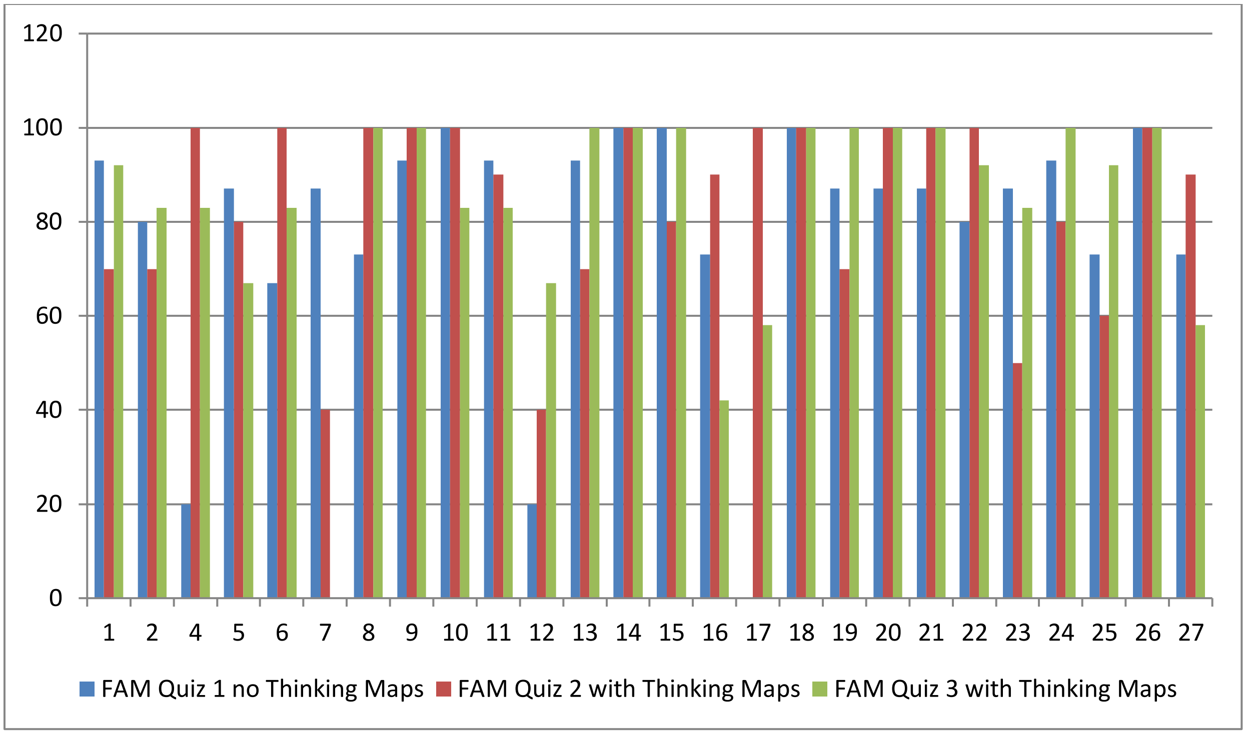

Figure 4. Participant Forces and Motion (FAM) quiz scores by percentage correct (n=26)

Table 3 reports participant raw test scores according to their Winter 2019 MAP score category in the area of Informational Text. The MAP test categorizes participants as Low, Low Average, Average, High Average, and High. No participants were categorized as Low or Low Average in these areas on the Winter 2019 MAP test. Participants fell into the Average, High Average, or High categories in Information Text. The mean score growth for the Average category was 5 points with a standard deviation of 1.41. The mean score growth for the High Average category was 3.6 points with a standard deviation of 2.64. The mean score growth for the High category was 4 points with a standard deviation of 2.30.

Table 3

Participant Raw Scores According to Informational Text reading ability based on Winter 2019 MAP test results (n=26)

Participant	Unit Pre-Test	Unit Post-Test	Points Increase
16	3	9	6
17	5	9	4
1	5	14	9
2	5	10	5
6	9	11	2
8	8	10	2
21	7	10	3
24	7	9	2
27	4	6	2
4	7	13	6
5	5	12	7
7	7	8	1
9	7	10	3
10	6	9	3
11	4	10	6
12	4	10	6
13	6	9	3
14	10	14	4
15	9	9.5	0.5
18	8	14	6
19	7	14	7
20	8	10	2
22	8	10	2
23	6	13	7
25	6	10.5	4.5
26	11	12	1

Note: Participants in blue are categorized as Average, participants in purple are categorized as High Average, and the participants not highlighted are in the High category.

Table 4 reports raw test scores of participants and is sorted according to their Winter 2019 MAP test category in the area of Vocabulary Acquisition and Use. Participants fell into the High Average or High categories in Vocabulary Acquisition and Use. The mean score growth for the

High Average category was 5.3 points with a standard deviation of 2.6. The mean score growth for the High category was 3.5 points with a standard deviation of 2.1.

Table 4

Participant Raw Scores According to Vocabulary Acquisition and Use reading ability based on Winter 2019 MAP test results (n=26)

Participant	Unit Pre-Test	Unit Post-Test	Points Increase
1	5	14	9
2	5	10	5
5	5	12	7
12	4	10	6
16	3	9	6
22	8	10	2
24	7	9	2
4	7	13	6
6	9	11	2
7	7	8	1
8	8	10	2
9	7	10	3
10	6	9	3
11	4	10	6
13	6	9	3
14	10	14	4
15	9	9.5	0.5
17	5	9	4
18	8	14	6
19	7	14	7
20	8	10	2
21	7	10	3
23	6	13	7
25	6	10.5	4.5
26	11	12	1
27	4	6	2

Note: Participants in blue are categorized as Average, participants in purple are High Average, and the participants not highlighted are in the High category.

Findings, Implications, Limitations

Findings

The study hypothesized that using Thinking Maps graphic organizers would increase participant comprehension of science nonfiction texts. Based on the data collected during the study, all participants grew in comprehension in the Forces and Motion (FAM) unit as measured by the unit pre- and post-tests. As a group, the participants grew by 4 points or 28.57%. Initially only 7.69% of the participants passed the pre-test with a score of 70% or above and no participants scored 80% or above. On the post-test 53.85% of participants scored 70-99% and 15.38% scored 100%.

The positive effects of Thinking Maps can be seen not only in the increase in test scores, but also in the FAM Quiz scores. When participants took the first FAM quiz they did not use any Thinking Maps graphic organizers. On that quiz, the group had a mean percent score of 82.038% correct. For the sections for FAM Quiz 2 and 3, participants used Thinking Maps such as Circle Maps, Tree Maps, and Multi-flow maps. On those quizzes, participants scored a mean percent of 83.846% and 86.64% correct respectively. Using Thinking Maps increased participant quiz scores by 4.602%.

Not every participant showed a steady increase in comprehension as measured by the quizzes. Twenty-five of the participants took all three of the quizzes. Thirteen of those participants increased their scores from quiz 1 to quiz 3. Eight participants' scores dropped and 4 participants' scores stayed the same as they had 100% for both quiz 1 and quiz 3.

The study also hypothesized that using Thinking Maps graphic organizers would increase the comprehension of participants who were categorized as Average or High Average more than participants who were categorized as High level on the Winter 2019 MAP test in the areas of

Informational Text as well as Vocabulary Use and Acquisition. In the area of Informational Text, the Average participants grew the most with a mean of 5 points while the High Average participants grew the least with a mean of 3.57 points and the High participants grew in between both with a mean of 4 points. In Informational Text, the lowest students did show the most growth both the High Average participants did not grow more than the High participants.

In the area of Vocabulary Acquisition and Use, there was no Average category as in Informational Text. The lower category, High Average did show more growth than the High level with a mean growth of 5.285 points while the High level grew a mean of 3.526. In Vocabulary Acquisition and Use, the lower level participants showed more growth than the High level participants. Participant 1, with the largest growth, was from the High Average category on both Information Text and Vocabulary Acquisition and Use and the participant 15, with the lowest growth, was from the High category in both Informational Text and Vocabulary Acquisition and Use. Overall, all participants showed growth when using Thinking Maps graphic organizers.

Discussion and Conclusion

The participants in the study were fifth graders, just above the third and fourth grade level when most science textbooks switch from a familiar narrative style to the unfamiliar expository style (Bostas, 2017; Roman, Jones, Basaraba, & Hironaka, 2016). The researcher found that participants did have trouble identifying the text structure and purpose for the texts they were reading (Scott & Dreher, 2016). Once the structure and purpose was identified, most participants were able to identify which Thinking Map should be used. Thinking Maps graphic organizers did help participants to be able to organize the information from their texts according to the purpose of the text and/or the lesson (Hall, Kent, McCulley, Davis, & Wanzek, 2013; Scott & Dreher, 2016).

The researcher discovered that participants would often ask the researcher how many pieces of information had to be on the Thinking Map they were working on. Participants had been so used to filling out pre-made graphic organizers with x-number of spaces that participants were not accustomed to simply putting down all of the information they could find. Many participants wanted to look for a certain number of facts and then stop as they were often used to doing.

As research suggested, when participants first began using the Thinking Maps, a lot of their focus and energy when into how to create the Map and how to do it correctly and less time and energy was put into focusing on content requiring more time to work than originally planned (Scott & Dreher, 2016). As participants became more familiar with each type of Thinking Map, less energy went into its creation and the participants could focus on the scientific content they were working with. By the last lesson, the researcher needed to spend minimal time with the participants reviewing the properties and purpose of the Maps being used.

Research on Thinking Maps emphasizes that the end goal of using Thinking Maps is not the Map itself, but being able to use the information on the Map to clearly communicate what was learned (Hyerle, 1996). The researcher would confirm, as research states, that using Thinking Maps improves the quality and quantity of student writing (Hyerle, 1996). Not every participant produced quality writing. Writing clearly, and with quality, for a purpose is a skill this group of participants generally struggles with. The researcher noted that many participants increased the amount they wrote on the assigned topic with quality information and presented in an organized, detailed manner. Creating the Thinking Map ahead of time had participants put a lot of information down and then organized it for them which made writing about the topic considerably easier.

Implications

Educators must continually assess their students and determine where each student is at when working with different content areas and topics. Comprehension is an important component and educators must find ways to help their students comprehend the information they are learning. Districts and states are requiring educators to use standards such as CCSS and NGSS among others when designing their lessons and assessing student achievement. These standards are increasingly demanding that students comprehend content on a deeper level and be able to communicate what they have learned in a meaningful way.

Thinking Maps graphic organizers are a useful took that educators can use for students of all ages and in all content areas. While using the Maps takes time initially to teach each map, how it is used, why it is used, and then how to use the information from the map to communicate as expected, once students have practiced often enough they learn how to use the maps appropriately and using the maps in class will take less time. Not every lesson will be a lesson in which Thinking Maps would be used to the degree they were in this study, but once students learn the maps they will always have those tools to use throughout their education and beyond.

Schools and school districts that would like their educators to use Thinking Maps in their classrooms must provide their educators with the proper training and support. Educators must first know how the Maps are used and how to identify which Map or Maps meet the purpose of the lesson in order for them to properly teach their own students how to use them. Schools must then allow educators and students time to work with Thinking Maps in order to become proficient and effective in using them.

Limitations

One limitation of the study was that only one classroom was part of the study. If another classroom or multiple other classrooms were part of the study then results could be compared for consistency or discrepancies. Along those lines, the small sample size was a limitation. Data was collected from 26 participants and only 25 of those had complete data for the quizzes. The results could be different with a different set of participants. There were also not an equal number of students in the different Average, High Average, and High categories with fewer in the lower categories. If the sample had more participants in the lower categories the data would give a better idea of how

An additional limitation was the number of absences for some participants. One participant was absent for one of the quizzes and their score was not included. Participants number 3 and 28 were absent almost the whole last week of the unit and were absent the day of the unit post-test. The post-test was given on the last day of the study which was also the Friday before spring break, so there was not time for those two participants to complete a make-up test in time to be included in the study, thus their data was not included in the study at all.

Another limitation was that this study only took place during one unit. If the study was done over multiple units, then one entire unit could have been done without any Thinking Maps graphic organizers and another unit could have been done completely with Thinking Maps graphic organizers and data on growth could have been compared between the two units.

Reflection and Action Plan

Reflection

Using Thinking Maps graphic organizers increased participant comprehension on the Forces and Motion Unit as hypothesized. The second hypothesis was also generally confirmed in the

FAM quizzes. The FAM quizzes also reinforce that Thinking Maps graphic organizers help students of all levels with comprehension, and especially participants who may be working on, or struggling with, informational text and vocabulary skills.

The researcher noted that working with Thinking Maps properly, allowing participants time to read the text, collaborate with classmates, compose their Thinking Map, share their Thinking Map, and then write a response from the Thinking Maps took more time than originally anticipated. As participants became more used to working with the maps and how class time and work time was being used when working with Thinking Maps, participants became more efficient with their time. In working with the participants, the researcher noted that participants liked using the Thinking Maps as a way to get their information out with little guidelines and limitations. Participants stated that writing about the topics assigned was easier when using the notes from the Thinking Maps. The researcher noticed that some participants still needed practice with learning how to write from the information on the Thinking Maps as some would simply, and incorrectly, restate the notes verbatim from the Maps as complete sentences in their written responses.

Action Plan

The researcher plans to continue using Thinking Maps in the classroom with all students. The researcher's school has included using Thinking Maps as one of the school's main types of notetaking strategies. While the school has offered training to teachers in the building twice last summer, not all teachers have gone through the training. The school has also not been financially able to purchase the online component of Thinking Maps that provides both teachers and students with resources for finding examples of different types of maps as well as being able to create maps digitally which many students would find very enticing. The researcher will continue to use student examples and progress as support for the school to continue to invest in teacher training and to provide the digital platform options.

The researcher would also like to continue with Thinking Maps in a more mixed-methods approach bringing in student surveys and feedback on the lessons and topics. The researcher is interested to see how using Thinking Maps may help improve student self-efficacy. The researcher observed that for most of the participants that using Thinking Maps when taking notes from the text was less intimidating compared to more traditional methods such as Cornell notes. The researcher would also like to hear from students how they felt about the content after using Thinking Maps and how they felt Thinking Maps may or may not have helped them comprehend the content. Not all participants preferred using Thinking Maps, so learning directly from the participants what their preferred note taking style was and why would be helpful in designing future lessons. The researcher would also like to continue working with students on how to properly communicate information from the maps without simply restating the notes.

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Appendix A

ROCKFORD PUBLIC SCHOOLS

Thurgood Marshall School
4664 North Rockton Avenue
Rockford, IL 61103-1529
815-490-5400

January 28, 2019

Dear Institutional Review Board Members,

As principal of Thurgood Marshall Middle school, I approve the appropriateness of Sarah Hall's project study titled *The Effectiveness of Thinking Maps on Science Nonfiction Text Comprehension*. Mrs. Hall discussed the components of the study as well as the expected outcomes. The project is age appropriate as fifth grade teachers work to increase student's comprehension as well as helping students to successfully navigate science nonfiction texts. Conducting the project at Thurgood Marshall Middle School is very feasible and should be completed before the end of the semester. If you have any questions, please contact me.

Sincerely,

Jill Faber

Jill Faber

Principal, Thurgood Marshall Middle School

faberj@rps205.com

815-490-5400

Appendix B

Parent Notification

Dear Parents/Guardians:

As part of my graduate work in Curriculum and Instruction at Eastern Illinois University I am conducting an Action Research project in my classroom this semester. This research project is a requirement to fulfill my master's degree course work.

I will be conducting a study that will assess students' comprehension of science nonfiction texts. I will be using Thinking Maps as learning tools, short quizzes throughout our scheduled unit and a unit test to assess comprehension. Students will be continuing in our curriculum as planned and receive the same instruction as the rest of the 5^{th} grade classes.

The time allotted for this research project is 6 weeks.

The results gathered from this study will be used for the purpose of this project. All data collected will be confidential and the outcomes that will be presented will not contain any specific identifying information. As parents or guardians you have the option to exclude your child form the study. Please contact me if that is the case.

I have been granted approval by the school to conduct this research project in my classroom.

If you have any questions or concerns about this project please feel free to contact me at any time.

Thank you,

Sarah Hall

Appendix C

Procedures and Data Collection Outline & Timeline

Week & Dates	Procedures/Lessons	Data Collected

1
Feb. 11-15
	Mon- **Google Forms Unit Pre-Test**
	• *Science* Ch. 13 Lesson 1 "How can you describe motion?"
	  o Discussion, notes, vocabulary
	Day 2: Introduce FOSS Force and Motion Unit
	  o Investigation 1: Here to There
	  o Begin building Air Trolleys
	Tues - Air Trolley testing
	Wed – Air Trolley data collection
	Thur – Air trolley data graphing
	Fri – Road Races activity
		Google Forms Unit Pre-Test

2 Feb. 18-22	Mon – NO SCHOOL Tues – **Force and Motion (FAM) Quiz 1 Air Trolley** Wed – *Science* Ch. 13 L. 2 "What are forces?" • Small groups use **Circle Map** graphic organizers to define different types of forces Thur – 13.2 Continued • Small groups continue **Circle Maps** Fri – 13. 2 Continued • Small groups present **Circle Maps** • Students create **Tree Map** to classify the different forces, their definitions, and examples based on shared information from circle maps	**FAM Quiz: Air Trolley** (no graphic organizers used in week 1) *Graphic Organizers Used:* • *Circle Map* • *Tree Map*
3 Feb. 25 – Mar. 1	Mon – FOSS Investigation 2 – Speed • Who Got There First activity Tues – Time Travel activity A Wed – Time Travel activity B Thur – Measuring Time & Distance • Speeding down slopes activity data collection Fri – Speeding down slopes graphing data	

4
Mar. 4 – 8
	Mon – **FAM Quiz: Speed**
	Tues – *Science* Ch. 13 L. 3 "What are Newton's Laws of Motion?"
	• Small groups create:
	  o **Circle Map** on Net forces, Equilibrium, Inertia, Acceleration
	  o **Tree Map** on Newton's 3 laws
		FAM Quiz: Speed
		
		Graphic Organizers:
		• *Circle Map*
		• *Tree Map*

4 Mar. 4 – 8	Mon – **FAM Quiz: Speed** Tues – *Science* Ch. 13 L. 3 "What are Newton's Laws of Motion?" • Small groups create: o **Circle Map** on Net forces, Equilibrium, Inertia, Acceleration o **Tree Map** on Newton's 3 laws Wed – *Science* 13.3 cont'd Thur – FOSS Investigation 6 – Force • Friction Activity Fri – Forces in Action Activity	**FAM Quiz: Speed** ***Graphic Organizers:*** • ***Circle Map*** • ***Tree Map***
5 Mar. 11 - 15	Mon – **FAM Quiz: Newton's Laws** Tues – *Science* Ch. 13 L. 4 "What are simple machines?" • Small groups create **Circle Maps** on the different simple machines: Pulley, Wheel & Axle, Lever, and Inclined Planes Wed – 13.4 cont'd • Groups share circle maps • Class creates a **Multi-Flow Map** with the center action being "Makes work easier by" • Assessment: Students will each write a paragraph detailing two simple machines, examples of each, and how that type of simple machine makes life and/or work easier. Thur – Unit wrap-up and review Fri – **Google Forms Unit Post Tests**	**FAM Quiz: Newton's Laws** ***Graphic Organizers:*** • ***Circle Map*** • ***Multi-Flow Map*** ***Written paragraph*** **Google Forms Forces and Motion Unit Post Test**

Appendix D

Ch. 13 Forces and Motion Pre-Test

Your email address (**sarah.hall@rps205.com**) will be recorded when you submit this form. Not **sarah.hall**?
Sign out
* Required

1. **Please type your name Last Name, First Name** *

____

Vocabulary

Read the questions and choose the best Answer

2. **The rate at which velocity changes over time is** *
Mark only one oval.
   - ◯ Acceleration
   - ◯ Velocity
   - ◯ Speed
   - ◯ Inertia

3. **An example of gravity at work is** *
Mark only one oval.
   - ◯ A stone and metal pins attracted to each other
   - ◯ Brake pads slowing down a wheel
   - ◯ A pendulum swinging

4. **The tendency to resist a change in motion is** *
Mark only one oval.
   - ◯ Inertia
   - ◯ Friction
   - ◯ Velocity
   - ◯ Equilibrium

5. **Magnetism is** *
Mark only one oval.
   - ◯ A force that pushes
   - ◯ A force that pulls
   - ◯ A force that pushes and pulls
   - ◯ None of the above

6. **Speed is** *

Mark only one oval.

- ◯ A force that slows motion
- ◯ A force that both pushes and pulls
- ◯ The act of changing position
- ◯ The distance an object travels in a unit of time

7. **Velocity is** *

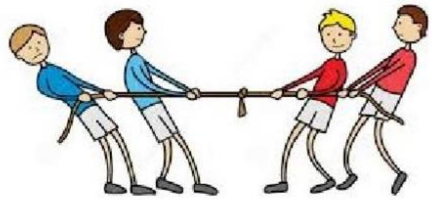
Mark only one oval.

- ◯ The amount of change of position between an initial position and a final position of an object
- ◯ The speed and direction of an object's motion
- ◯ How fast an object is going
- ◯ The act of changing position

Multiple Choice

Read each question and choose the best answer

8. **Look at the picture below. What needs to happen for the flag on the rope to move to the left?** *



Mark only one oval.

- ◯ The red team needs to pull with more force than the blue team
- ◯ The blue team needs to pull with more force than the red team
- ◯ The red and blue teams need to pull with equal force
- ◯ The red and blue teams need to push with equal force

9. **A man pushes on a wall. Which statement is true?** *

Mark only one oval.

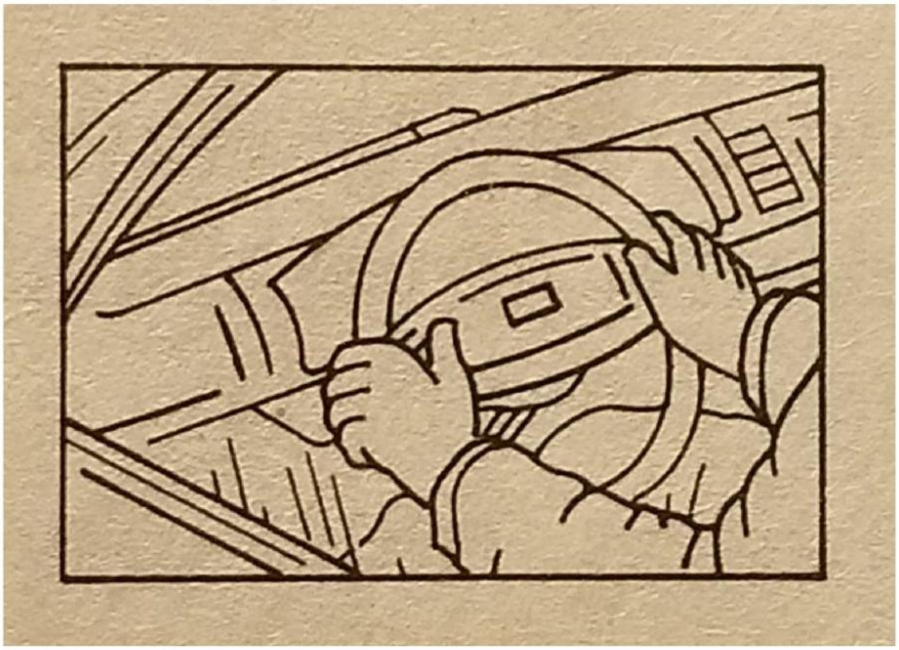
- ◯ The man exerts more force on the wall
- ◯ The wall exerts more force on the man
- ◯ The man and the wall exert equal force on each other

10. **To find the net force acting on an object** *

Mark only one oval.

- ◯ Multiply the mass times acceleration
- ◯ Multiply gravity times weight
- ◯ Add the mass and velocity
- ◯ It is impossible to find the net force of an object

11. **How is the driver using a simple machine?** *



Mark only one oval.

- ◯ The driver is using a pulley and lever to steer the car
- ◯ The driver is using a wheel and axle to reduce the amount of force needed to steer the car
- ◯ The driver is using a wheel and axle to reduce the amount of work needed to steer the car

Short Answer

Please answer each question by restating the question into the answer. Use complete sentences, proper capitalization, and correct punctuation.

12. **What forces will act upon a toy car rolling down an inclined board? Be specific and give examples to support your answer.** *

13. **Identify two simple machines and explain how they make work easier. Provide an example of each simple machine you identify.** *

Appendix E

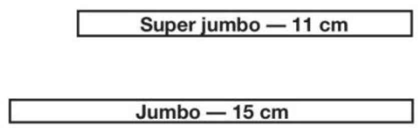
AIR-TROLLEY CONSTRUCTION

Materials

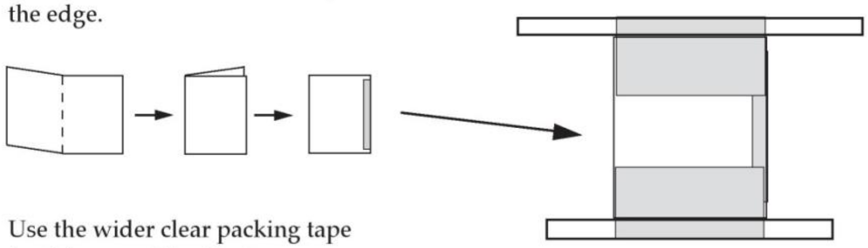
1 Jumbo straw	1 Rubber band
1 Super jumbo straw	1 Meter tape
1 Index card	1 Scissors
1 Propeller	• Transparent tape
1 Hook	• Clear packing tape, 2″ wide

a. Cut the super jumbo straw (larger diameter) at 11 cm.

Cut the jumbo straw at 15 cm.

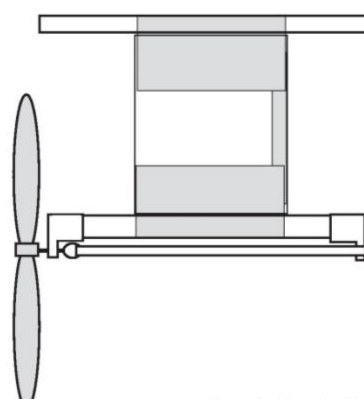


b. Fold the index card in half. Tape the edge.



c. Use the wider clear packing tape for this assembly. Center everything before taping. Tape the two straw pieces to the short edges of the folded card.

d. Attach a propeller to one end of the super jumbo straw and a hook to the other end. Connect the propeller and hook with the rubber band.



Appendix F

Name ______________________________

Period __________ Date ______________

AIR-TROLLEY DISTANCE GRAPH

Part 1: Gather air-trolley flight data.

1. Number of winds on the propeller ________________

2. Measured flight distances during five trials

Trial	Distance (cm)

3. Average flight distance

____

Part 2: Graph the air-trolley flight data.

Title ______________________________

Winds	*d* (cm)

FOSS Force and Motion Course

Investigation 1: Here to There
Student Sheet

Appendix G

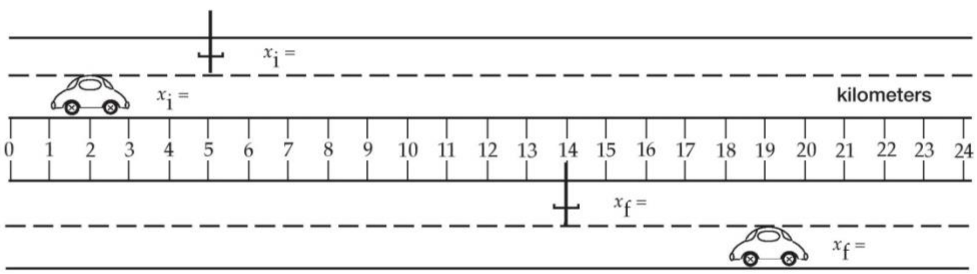
Name ______________________

Period ____________ Date ______________

ROAD RACES A

Write the equation for calculating distance. ______________________

Road Race 1 One person drove a car, and the other rode a pogo stick.



Which vehicle went farther?

____

How much farther?

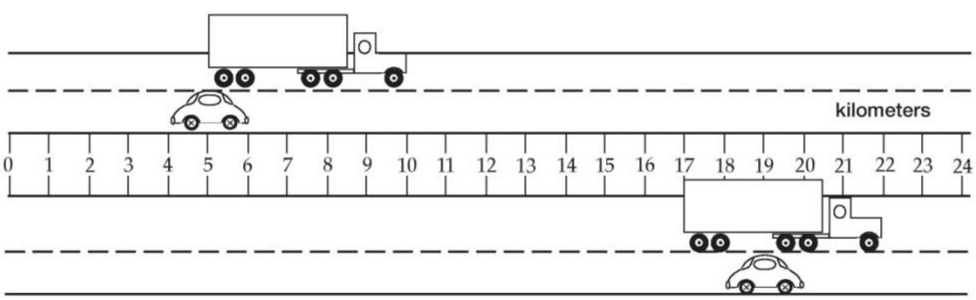
____

Pogo-stick math here.

Car math here.

Difference math here.

Road Race 2 One person drove a truck, and the other drove a car.



Which vehicle went farther?

____

How much farther?

____

Math here.

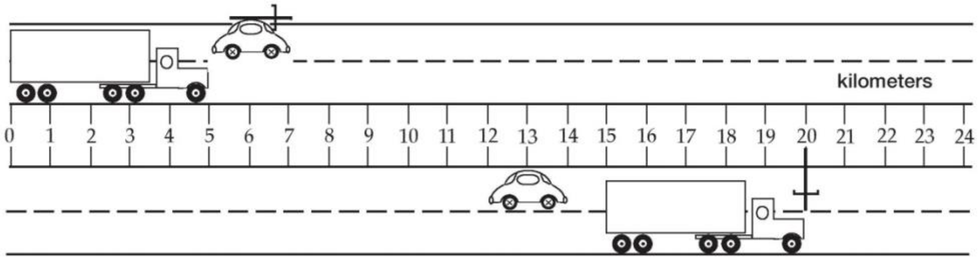
Math here.

Name ____________________

Period __________ Date ______________

ROAD RACES B

Road Race 3 One person started in a car, ran out of gas, and finished on a pogo stick. The other person drove a truck.



Which of the three vehicles went the greatest distance?

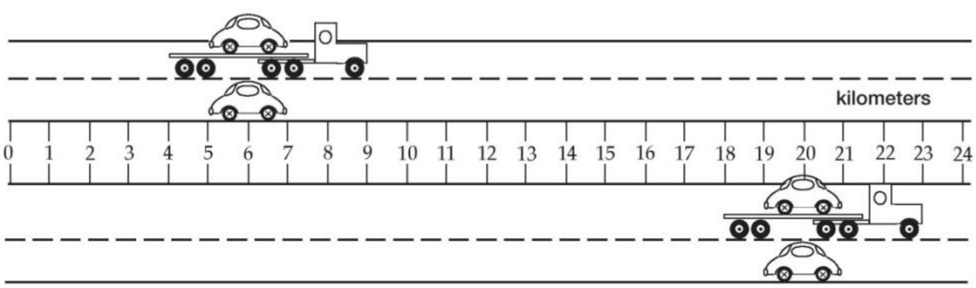
____

Which vehicle went the shortest distance?

____

Math here.

Road Race 4 A truck hauling car A raced against car B.



Which of the three vehicles went farthest?

____

How much farther?

____

Math here.

FOSS Force and Motion Course

Investigation 1: Here to There
Student Sheet

Appendix H

Forces and Motion: Air Trolley Quiz

Name: ______________________________

Date: _________________ Class: _________

1. Find the definition that matches the word or phrase in the "term" column. Write the letter in the "definition" column. Write the symbol that is used to represent the term. If the term does not have a symbol, write "no symbol."

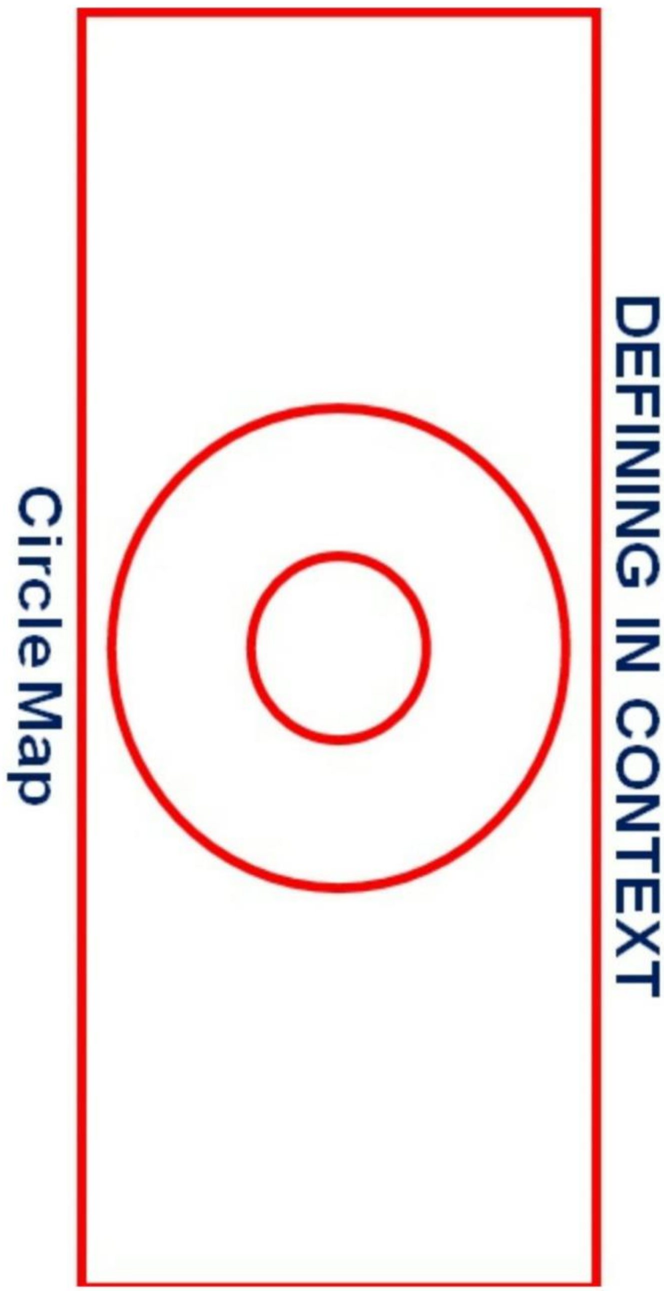
<table>
<tr><th>Term</th><th>Definition</th><th>Symbol</th><th>Definitions</th></tr>
<tr><td>Position</td><td></td><td></td><td rowspan="6">A. The amount of change of position between an initial position and a final position.
B. The starting place
C. Change
D. The ending place
E. An object's location at any given time
F. The act of changing position</td></tr>
<tr><td>Motion</td><td></td><td></td></tr>
<tr><td>Delta</td><td></td><td></td></tr>
<tr><td>Distance</td><td></td><td></td></tr>
<tr><td>Initial Position</td><td></td><td></td></tr>
<tr><td>Final Position</td><td></td><td></td></tr>
</table>

2. Write the equation used to calculate distance: ________________________________

3. In your own words, describe, "*What is Motion?*"

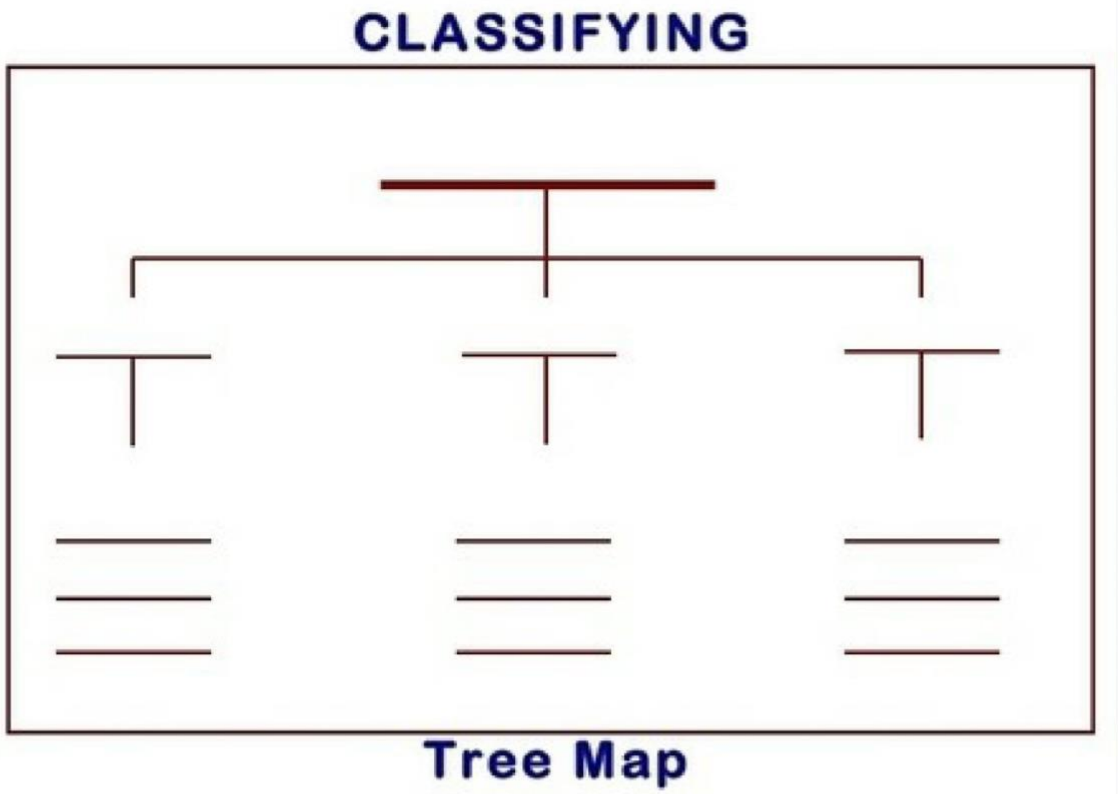
Appendix I

Thinking Maps Circle Map – For brainstorming or defining



Appendix J

Thinking Maps Tree Map – Main Idea and Details



Appendix K

Name ______________________________

Period __________ Date ________________

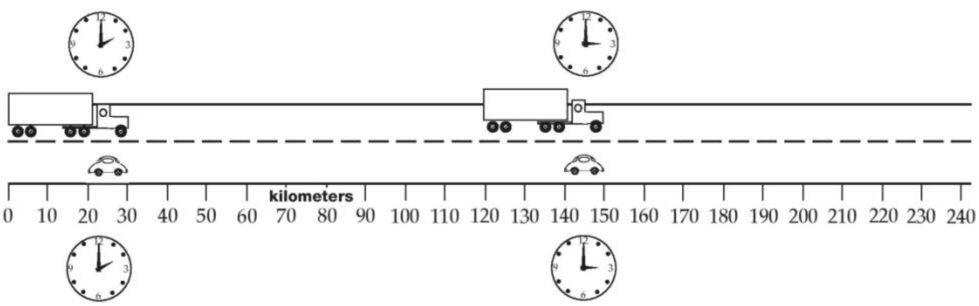
WHO GOT THERE FIRST? (race 1)

Look at race 1 between the truck and car.

Neither of the vehicles changed speed during the race.

Which vehicle reached the **150-kilometer mark first?**

Race 1



Truck *d* = __________ Truck time interval = __________

Car *d* = __________ Car time interval = __________

Which vehicle reached the 150-km mark first? ______________________________

How do you know? ______________________________

____

____

____

Show math here.

Appendix L

Name ______________________________

Period __________ Date ______________

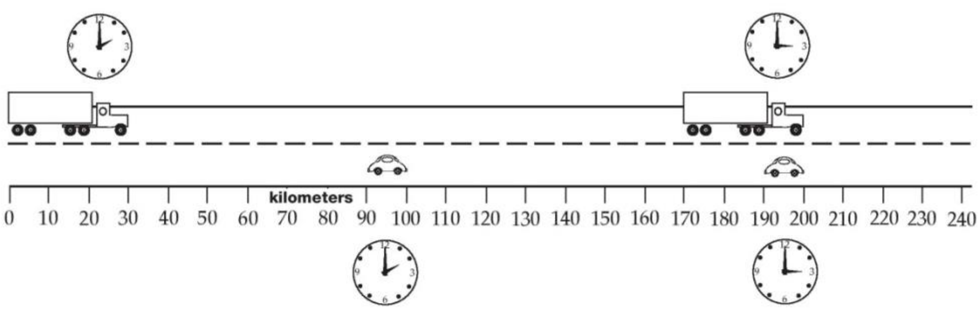
WHO GOT THERE FIRST? (race 2)

Look at race 2 between the truck and car.

Neither of the vehicles changed speed during the race.

Which vehicle reached the **150-kilometer mark first?**

Race 2



Truck *d* = __________ Truck time interval = __________

Car *d* = __________ Car time interval = __________

Which vehicle reached the 150-km mark first? ______________________________

How do you know? ____

____

____

____

Show math here.

FOSS Force and Motion Course

14

Investigation 2: Speed
Student Sheet

Name ______________________

Period ____________ Date ______________

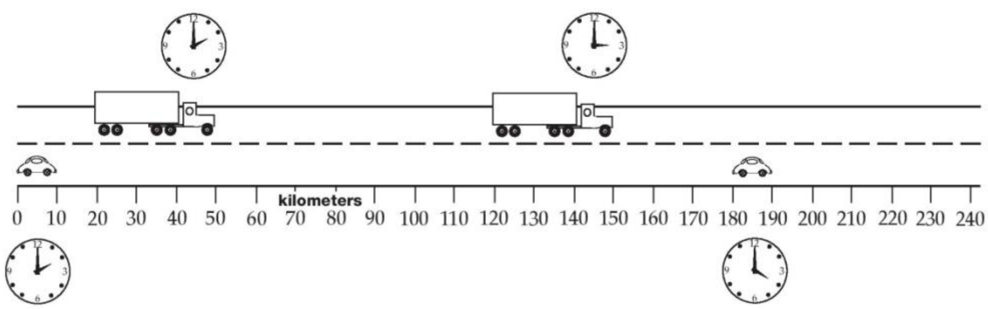
WHO GOT THERE FIRST? (race 3)

Look at race 3 between the truck and car.

Neither of the vehicles changed speed during the race.

Which vehicle reached the **150-kilometer mark first?**

Race 3



Truck d = ____________ Truck time interval = ____________

Car d = ____________ Car time interval = ____________

Which vehicle reached the 150-km mark first? ______________________

How do you know? ______________________

____

____

____

Show math here.

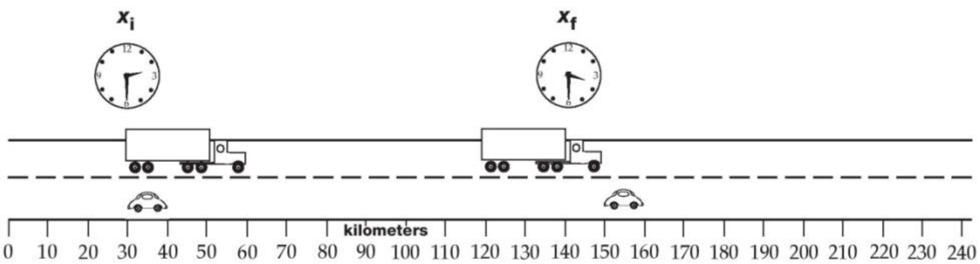
Appendix M

Name ______________________________

Period __________ Date ______________

TIME TRAVEL A

1. At 2:30 p.m. a car and a truck were in the positions shown at x_i. At 3:30 p.m. the car and truck were in the positions shown at x_f. They traveled at steady speed all the time.



Show math and units in these boxes.

a. How far did each vehicle travel?

Truck ____________

Car ____________

b. How long did it take the vehicles to get to their positions at x_f?

____

c. How fast was each vehicle going from x_i to x_f ?

____

d. What is the equation for calculating **speed?**

e. Which vehicle got to the 100-km mark first?

____

How do you know?

____

____

____

FOSS Force and Motion Course

Investigation 2: Speed
Student Sheet

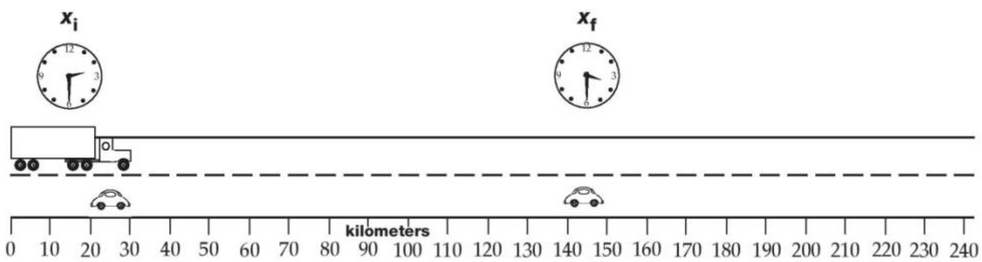
16

Name ______________________________

Period ____________ Date ________________

TIME TRAVEL B

2. This time the vehicles started at the positions shown at x_i, but the truck was going **half as fast** as it was in problem 1.



Show math and units in these boxes.

a. Where would the **truck** be at 3:30 p.m.?

____

b. How far would the **truck** have traveled at 9:30 p.m.?

____

c. How far would the **car** have traveled at 3:00 p.m.?

____

d. What is the equation for calculating **distance when you know the speed and time?**

e. What is the total distance traveled by **both vehicles** (added together) at 5:00 p.m.?

____

FOSS Force and Motion Course

17

Investigation 2: Speed
Student Sheet

Appendix N

Name ____________________

Period __________ Date ______________

SPEEDING DOWN SLOPES

Part 1: Gather data.

a. The elevation your team worked with was ______________ .

b. The distance you ran your car was 200 cm .

c. You ran ________ trials.

d. Enter your raw data. →

e. Calculate the **average time** it took the car to travel 200 cm. Use a calculator.

Time trials (s)

f. Calculate the car's **average speed.** Write the equation and show your math.

Average time

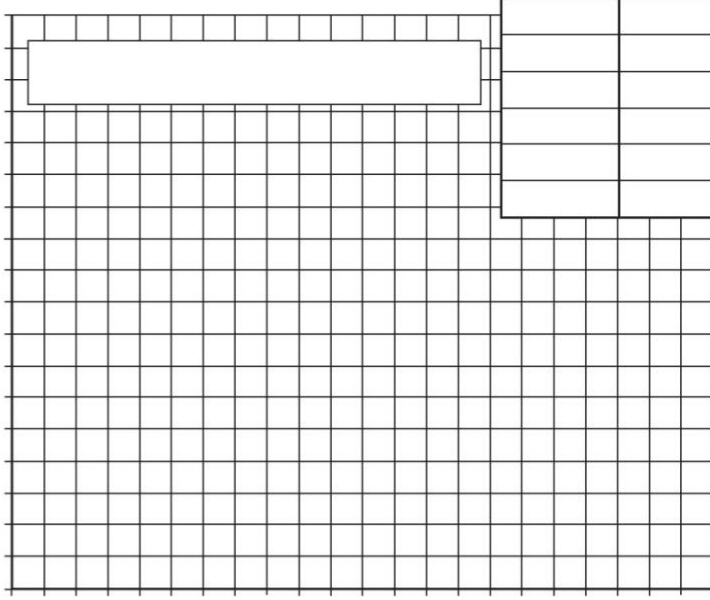
Average speed

Part 2: Graph results.

a. Copy the other teams' time and elevation data to your table.

b. Graph distance versus time for each elevation.

Elevation (cm)	Average Δt (s)	*d* (cm)
		200
		200
		200
		200
		200



Appendix O

Forces and Motion: Speed Ramp Quiz

Name: ________________________

Date: _____________ Class: ______

Match the vocabulary term with the definition or characteristic. Write the letter in the space next to the vocabulary term. Do not draw lines to connect them.

___ 1. Friction	A. is done when a force moves an object
___ 2. Magnetism	B. the rate at which work is done
___ 3. Power	C. the distance an object travels in a unit of time
___ 4. Speed	D. a force that slows motion
___ 5. Work	E. a force that both pushes and pulls

Circle the answer that makes the following statements correct

6. Objects with opposite charges (**attract** / **repel**) each other.

7. Speed is dependent on (**distance** / **time** / **both** / **neither**).

Answer the following questions.

8. What is speed? ____

____

____

____

9. The distance between Maylee's home and the zoo was 100 meters. She walked 1 m/s for 1 minute. How many meters were left before she reached the zoo? Show your math.

Appendix P

Forces and Motion: Newton's Laws of Motion

Name: ______________________________
Date: ______________ Class: __________

Match the vocabulary term with the definition or characteristic. Write the letter in the space next to the vocabulary term. Do not draw lines to connect them.

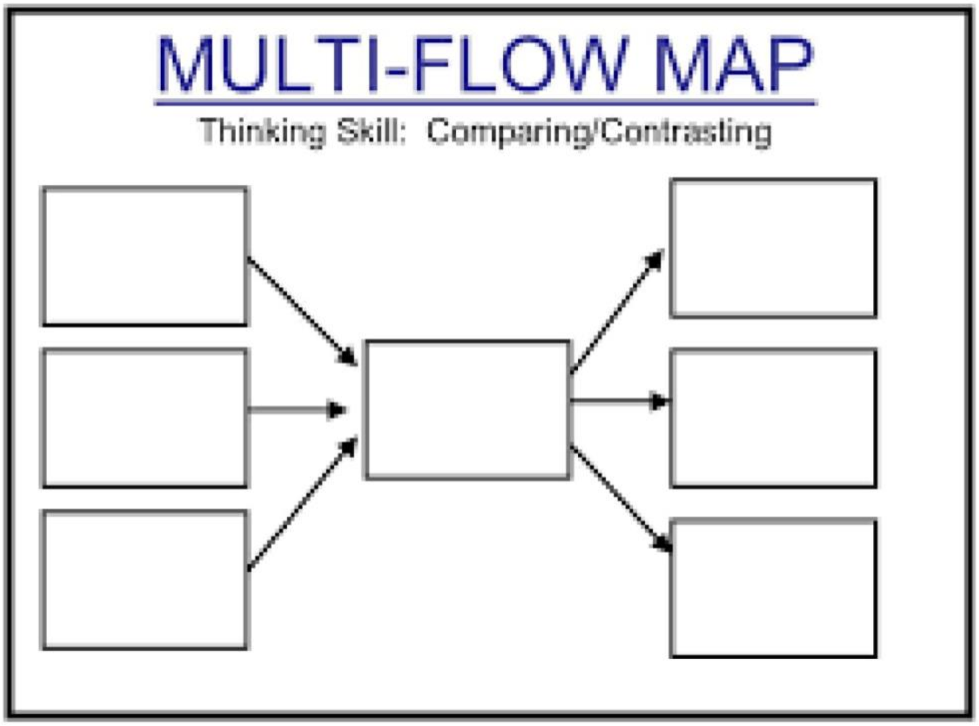
Term	Definitions
____ acceleration	A. when the forces on an object are unbalanced
____ change in motion	B. the tendency to resist a change in motion
____ equilibrium	C. when all acting forces on an object are balanced
____ inertia	D. the combination of all forces on an object
____ net force	E. the rate at which velocity changes over time

Read the following definitions, statements, or examples in the "Read" column below. After each one state which of Newton's Laws of Motion best apply and write the term in the "Respond" column. Use the following terms; Newton's First Law, Newton's Second Law, or Newton's Third Law.

Read	Respond
A force must have an equal and opposite force	
The stronger the force on an object the greater the acceleration	
An object in motion wants to stay in motion unless a net force acts upon it.	
The action-reaction law of motion	
Force equals mass times acceleration	
When an object exerts a force on a second object, the second object exerts a force on the first object	
An object at rest wants to stay at rest unless a net force acts upon it.	

Appendix Q

Thinking Maps Multi-Flow Map – Cause and Effect



Appendix R

Ch. 13 Forces and Motion Test

Your email address (**sarah.hall@rps205.com**) will be recorded when you submit this form. Not **sarah.hall**? Sign out

* Required

1. **Please type your name Last Name, First Name** *

Vocabulary

Choose the best option for each question

2. **How do electricity and magnetism act on different objects?** *

Mark only one oval.

- They can pull objects
- They can push objects
- They can either push or pull objects
- They can either push or pull objects only if they touch

3. **What force keeps a satellite in orbit?** *

Mark only one oval.

- Friction
- Gravity
- Electricity
- Magnetism

4. **The distance an object travels in a unit of time** *

Mark only one oval.

- Speed
- Distance
- Motion
- Velocity

5. **When you ride a roller coaster, what makes your body rise out of its seat at the top of a hill?** *

Mark only one oval.

- Inertia
- Gravity
- Friction
- Electricity

6. **The rate at which velocity changes over time is** *

Mark only one oval.

- Velocity
- Speed
- Acceleration
- Inertia

Multiple Choice

Read each question and choose the best answer

7. **How can you complete the sentence so it is always true? The greater the net force acting on an object,** *

Mark only one oval.

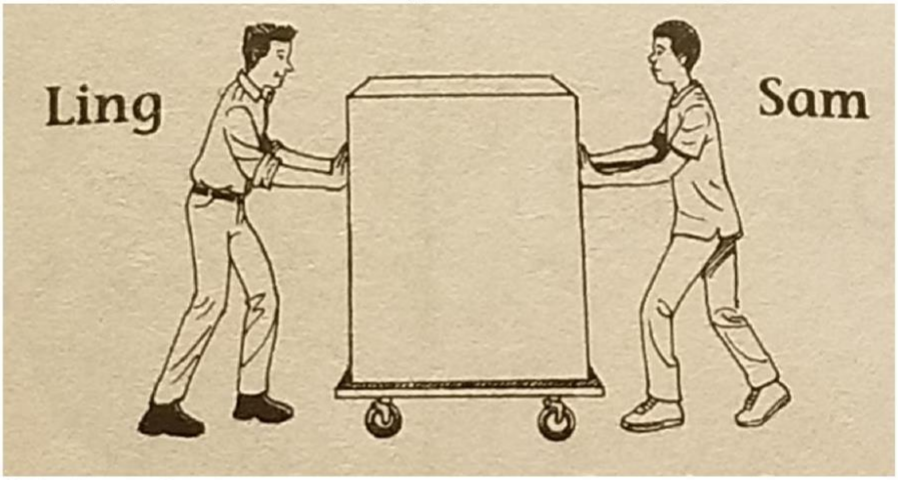
- the less the mass of the object
- the greater the mass of the object
- the less the acceleration of the object
- the greater the acceleration of the object

8. **A truck hits an insect. What effect does the insect have on the truck?** *

Mark only one oval.

- The insect has no effect on the truck.
- The insect hits the truck and the truck hits the insect with the same amount of force.
- The insect hits the t ruck with less force than the force with which the truck hits the insect.
- The insect hits the truck with more force than the force with which the truck hits the insect.

9. **Look at the picture below. What needs to happen for the box to move to the right?** *



Mark only one oval.

- ◯ Sam needs to push the box with more force than Ling.
- ◯ Ling needs to push the box with more force than Sam.
- ◯ Same and Ling need to push the box with equal amounts of force.
- ◯ Sam and Ling need to pull on the box with equal amounts of force.

10. **Which complex machine uses mainly human force to operate the simple machines in it?** *

Mark only one oval.

- ◯ car
- ◯ ship
- ◯ bicycle
- ◯ go cart

Short Answer

Please answer each question by restating the question into the answer. Use complete sentences, proper capitalization, and correct punctuation.

11. **Identify two simple machines and explain how they make work easier. Provide an example of each simple machine you identify.** *

____

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12. **What forces are acting upon the Air Trolleys as they move across the fishing line? Be specific and give examples to support your answer.** *

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