Ninepins, Tops, Atl-atls: The Physics of Colonial Era Tools and Toys

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Rationale

At the beginning of the year, I use atl-atls and hand-spindles as props in covering non-fiction conventions as part of the introduction to the 4th grade social studies textbook during the first six weeks of school. In September, the atl-atl, a class-1 lever, was an amazing technological innovation that increased the throwing range of an aboriginal hunter by extending the rotation radius of the wrist,[1] would be nothing more than a curious bit of realia to pique a child's interest-- an example of a tool used by humans for 10,000 years or so before being superseded by the bow and arrow. Towards the end of the year, these tools reappear along with games to teach science concepts. Physics and Libraries may seem an odd combination, but in reality, Media Specialists often find themselves teaching mini-lessons on a variety of subjects, including the science that tries to explain the workings of the universe.

Classic games such as Marbles, Billiards, Paille-Maille would have been known to the early settlers, but these games can also be used to teach about inertia, motion, momentum and energy. Hoop & dart games played by the Native Americans can be used to demonstrate acceleration and velocity. Ninepins, battledore & shuttlecocks allow students to experience force and sound energy. Tops and even hand-spindles demonstrate inertia, air resistance, and force.[2] I intend to use classic games and sports, as well as their modern equivalents to spark inquiry into research into Newton's laws. This curriculum unit will use some toys, tools and games to reinforce physics concepts.

I teach grades K-5 in a more or less fixed schedule that includes a period for checking out books, so the actual direct instruction time is 25 minutes once a week, perhaps less if the students are working on a guided activity. Special Area teachers will see classes only 4-6 times, depending on the length of the term, holidays or other scheduled events. This is important to note, as all Special Area teachers have a curriculum to teach and state standards to follow. In addition to our own curriculum, we are required to cover core content. The amount of time in which to make an impact is limited. Often teaching has to be broken up into two-week lessons, with the first being primarily direct instruction and the second, a lesson that features a quick review and a guided or independent activity. In Grades 3 - 5 classes, the focus is on learning to locate and use information. Media also works closely with grade-level Global Studies, units through which the core curriculum is taught and a global perspective explored.

What I propose are essentially Grade 3-5 lesson sets presented between October 2011 and June 2012 that present some information and activities inspired by the Sports and

Physics seminar. In addition to the lessons, there will be topical book displays, posters or prints and realia related to the unit on display in the Library Media Center. Atl-atls, darts, spinning wheels, spindles and game-pieces will come from my personal collection. Toys and Physical Education equipment will be borrowed from the school. Local history museums are a good source for re-enactors can demonstrate the use old tools and toys. They are a source for “curiosity” or “discovery” kits that can be loaned to a school for short periods of time. Suggested resources are included at the end of this curriculum unit.

Strategies

The Common Core sub-topics that I would like to cover in my unit relate to motion, force and energy. Since Winding Springs is a Global Studies school, the focus of lessons is international. In Media Classes, students would be guided to form essential questions about their units of study, and to research topics related to energy (light, sound, heat, magnetic, electric), motion and force. These units of study will depend heavily on collaborative teaching with home-room teachers.

As a Media Specialist, I provide access to Internet resources, reference and traditional non-fiction print materials, in addition to creating story-time programs and Big6 research lessons that support students’ interests. It is my job as a Media Specialist to find funding, collaborate on instruction, coordinate resource sharing, design lessons and teach research skills using international sports, games and toys to enhance understanding of physics.

My primary inspiration this year will not be literature, but multimedia and realia. Grade 3 will have two sets of lessons that will focus on hands on activities and journaling, learning about Galileo, Newton and Da Vinci and making observations about motion, force, mass and displacement. Grade 4 lessons will use primarily electronic resources such as videos from Discovery Education on forms of Energy as well as some hands on activities. The focus in Grade 5 will be applying knowledge, making observations and predictions as part of designing experiments. A list of materials and an annotated list of resources will be included at the end of this curriculum unit.

Ideal teaching activities would begin with a real-world or simulated problem, or a question that needs to be answered (problem-based Inquiry). The primary method of instruction will be using cooperative play activities that will feature small groups of students working together to learn. I plan to use discussion to allow students to actively learn by talking as well as listening. Informal Questioning will be used as both formative assessment and an ice-breaker. Thinking-Aloud, using "I wonder..." statements, is another strategy that will be used to start discussion. I plan to have students pose their own questions for the Questions & Answers Sticky-note Inquiry Board as well as asking some of my own. I will be integrating technology to enhance the learning experience when possible, through the use of multimedia and the interactive white board.

Active learning includes hands-on activities, observation, discussion, writing and reflecting in daybooks/journals. One of the discoveries I made in implementing the unit, was how critical writing is in assisting the mind to process science; writing provides the necessary contemplative time for the brain to process the idea as well as forces the learner to clarify concepts as they are recorded on paper. Not only are we studying mechanics, the study of motion, but also working on kinematics, how we describe the motion of object and to do that we need to use interactive science notebooks. The use of science notebooks is crucial because these journals allow students to connect their own concrete experience with the science concepts and vocabulary being taught. Creating graphics allow them to actively engage with the subject.[3] Recording their personal observations and learning to make inferences develops critical thinking. Notebooks are not only records of contemplation and reflection so necessary in interpreting and analyzing information; they serve as an assessment tool for both student and teacher. Since I am serving 16 different homerooms, with different approaches to managing paper, I will be asking students to create foldables, tables and charts, as well as using graph paper so that these visual notes can be clipped into binders or taped into their notebooks.

Visual Literacy

In Media classes, I teach that visual information comes in many forms from simple signs and icons, to photographs, videos, maps, graphs and charts, to complex cutaways, trees and flow-charts. There are simple and analytic diagrams, process diagrams such as timelines and storyboards, diagrams that show relationships and graphs which rank, measure and compare. This is because people are able to understand visual texts often before they can read the written language, as evidenced by the development and use of international signage.[4]

Visual literacy refers to the ability to read and interpret images, a critical skill for information and creative workers in our global society. Visual “texts” are often an alternative to words, but more importantly, images and words together help learners interpret, retain and synthesize new information as well as communicate more effectively. Images help learners understand abstract ideas and conceptualize solutions. The act of summarizing information in visual form forces the learner to reprocess the information in order to present it.[5] In teaching science, this is particularly important because relationships in science are not necessarily linear, nor are they expressed well solely in text, which is why teachers should use experiential teaching methods.[6] In this unit, students will be asked to interpret what they observe by the use of simple probing questions, as well as communicate using numbers, language and images.

Background Concepts and Vocabulary

Physical Science in Elementary years is primarily based on the work of Isaac Newton, who pondered the workings of the universe and proposed a set of observations which still guides our thinking today on classical mechanics.[7] Physics has its own set of vocabulary to describe concepts, which as discussed above, is a necessary part of learning to think and write objectively, scientifically. Also crucial to the understanding of Physics is the ability to express the concepts graphically. This unit is about Forces and Motion and so we must begin with how to describe both concepts linguistically, mathematically and graphically.

Force is simply the interaction of two objects upon each other,[8] existing only in the moments of interaction. These can be forces of attraction or repulsion. Forces can be those of direct contact and those that work from a distance. Contact forces include: Friction, Air Resistance, Tension, Applied, Spring forces. Forces that work from a distance include: Electrical, Magnetic and Gravity. Force is measured in a standard unit, called a Newton (N), which is the force required to move a kilogram of mass one meter per second or N = 1kg* m/s^2. Therefore, Force is equal to the change in momentum per change in time.[9]

Motion is described in terms of Speed, Velocity and Acceleration. Speed is the distance traveled divided by a unit of time, simply how fast something is traveling. Velocity can be described in terms of distance traveled as well as the measure of displacement. So, the path of travel is the measure of Distance, while net shift of an object from its initial point to another point is Displacement. Distance and Speed are Scalar quantities which only describe the range traveled in numerical terms.

$$Average\ Speed = Distance/Time$$

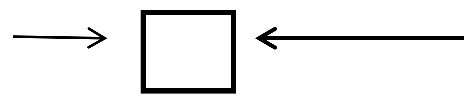
Common examples of speed are meters per second and miles per hour. Velocity, however, is a Vector quantity describes displacement in terms of both Speed and Direction, or more specifically, speed in a direction. Momentum is an example of a vector quantity.[10]

$$Average\ Velocity = \Delta\ Posititition/Time$$

Acceleration is the rate of the change in velocity during an interval of time. Acceleration can be either a change in speed, direction or both. Furthermore, any time there is an acceleration, a net or unbalanced force is present.

Acceleration = Change in velocity/Time interval

The challenge for students is to describe and depict speed, velocity and acceleration as they demonstrate their understanding of Newton's Laws. In physics, objects are frequently pictured as boxes and forces are depicted as arrows pointing in the direction of the force applied. I would expect students to represent the objects more conventionally, however, by drawing pictures of the objects themselves. The length of the arrow represents size of force, while the orientation of the arrow represents the vector direction. The example below shows that the force being applied to the object to the right is less than the one being applied to the left.



Elementary students will be expected to use the convention of representing force with arrows. Therefore, students will be expected to demonstrate their understanding of forces using these standard symbols in their notes.

Newton's Laws

As far back as 4 B.C., Aristotle wrote on the subject of motion. He theorized that the most natural state of objects was to be at rest and that all motion was caused by a mover. Natural motion, such as the speed of an object's fall, was related to the weight of the object as heavy objects fall faster. Aristotle also theorized that speed was affected inversely by the medium through which the object was falling. [11]

In 1638, Galileo disagreeing with Aristotle stated; "A falling body accelerates uniformly: it picks up equal amounts of speed in equal time intervals, so that, if it falls from rest, it is moving twice as fast after two seconds as it was moving after one second, and moving three times as fast after three seconds as it was after one second. " [12] What Galileo saw was that the rate of an object's fall accelerates, as an object falls, it increases in velocity; the greater the distance of the drop, the faster the acceleration of the object.

But Galileo noted that all objects resist change in their motion, what he termed "inertia". Newton expanded upon Galileo's idea of inertia, writing; "Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it."[13] So an object is said to be balanced when the forces acting upon it are equal. In a perfect universe the object would be either still forever and ever or moving in a straight path at a constant speed throughout eternity. But we do not live in a perfect universe; other forces are present that act upon us—such as gravity, expressed mathematically below:

$$F = mg$$

Gravity is one of the factors that affect motion and force, which are measured in terms of change of speed and direction. According to Newton, Gravity is a predictable and constant force in our universe. Force is proportional the product of both masses being affected, and inversely proportional to the distance between the two objects.[14] Just as apples fall to the Earth, so must the Earth be drawn towards the greater mass of the Sun. The Sun, according to Newton, is equally pulled in the opposite direction towards Earth. Newton's law of Universal Gravitation can also be expressed mathematically as:

$$F \propto \frac{m_1 m_2}{d^2}$$

Weight, often confused with mass, is the force of Gravity upon a Mass. Mass is the amount of material that makes up an object and exists independent of location. Mass, therefore can be considered a measure of Inertia because it resists acceleration.

"The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed."[15]

Forces cause acceleration. Acceleration is equal to the net force applied against the mass of the object divided by the mass, expressed below:

$$acceleration = \frac{net\ Force}{mass} \quad \text{or, more simply,} \quad a = \frac{F}{m}$$

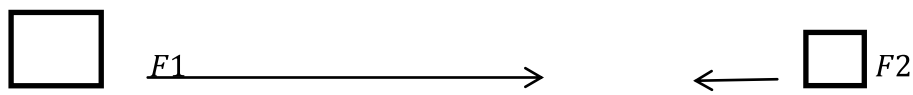
So, net force is the combined effect of all forces acting upon an object. Newton explained further that:

"— If a force generates a motion, a double force will generate double the motion, a triple force triple the motion, whether that force be impressed altogether and at once, or gradually and successively. And this motion (being always directed the same way with the generating force), if the body moved before, is added to or subtracted from the former motion, according as they directly conspire with or are directly contrary to each other; or obliquely joined, when they are oblique, so as to produce a new motion compounded from the determination of both. "[16]

Therefore, if the net force applied to an object unbalances it, the object accelerates, changing speed and/or direction. Simply put, if force is increased, then so is acceleration and if mass increases, then acceleration decreases. But as any teacher who has ever had to monitor a line of students knows, it would be remiss not to consider the idea of reaction, because according to Newton;

"To every action there is always opposed an equal reaction: or, the mutual action two bodies upon each other are always equal, and directed to contrary parts"[17]

There are no interactions without forces, nor are there forces without interaction. What this means is that whenever two objects interact, forces are present—both active and reactive, but these forces do not act upon the same object. If a ball strikes a bowling pin, the ball pushes against the pin and the pin pushes the ball. What then, causes the pin to topple if active and reactive forces are equal?



The difference is in the mass of the two objects. In the illustration above, F1 represents the ball and F2 represents the pin and the arrows represent direction and magnitude of the force. When the masses are different, the overall effect -- the net effect -- of the force causes the object with less mass to accelerate as illustrated below.

Fifth Grade Friction | Activity 1: Shove Ha'penny

Key Question: What changes speed? (What is friction?)

Fifth Graders are expected to be able to explain how factors such as gravity, friction, and change in mass affect the motion of objects. Gravity, which was introduced in 3rd Grade will be reviewed. Gravity is the force of attraction all matter exerts. Mass affects the amount of attraction a body has; the greater the mass, the greater the effect or force of gravity. However, distance is also a factor in gravitational pull; the further apart objects are, the less attraction there is between the two masses. Students must predict the effect of a given force or a change in mass on the motion of an object. Weight is the force of gravity acting upon a body; whereas mass is the amount of matter in an object. Mass is consistent regardless of gravity, so mass is considered a measure of inertia. Weight, however, is gravity dependent.

Friction is the resistance that changes the acceleration of an unbalanced object. Fifth graders might be fairly familiar with contact forces such as friction, tension, air resistance and spring forces, without understanding the difference between them. Friction occurs when two objects are in contact with each other when motion is a factor. Static friction occurs when an object resists motion. Sliding friction exists when resistance to motion occurs as one object moves against another. Tension force is one that is transmitted through guy-lines while spring tension refers to force that is stored and transmitted through compression and release.

Background:

Shove Ha'Penny is a type of table game played on slate or wooden boards dating back to the 1400's[18], reached the height of its popularity in the 1870s and is still played in public houses today. It has evolved into the more familiar outdoor variation known as Shuffleboard, which is played with puck and paddles. Traditional Shove Ha'penny, also known as Shuffle-Groat and Push Penny is played on a 20" long x14" wide board marked with 10 horizontal lines beginning 4" from the front of the board and ending with the last line 5" from the end of the board. The spacing between the lines is 1.25" wide and the space is called a bed. Each player slaps 5 ha'pennies during his/her turn with thumb, palm or fingertips; with the object of landing 3 ha'pennies in squarely in each of the 9 beds. Pennies that straddle the lines do not count towards the score. Score is kept on either side of the board, marked by vertical lanes 1.25" wide. Wooden boards are treated with wax to reduce friction, while slate boards are treated with talc or chalk.

Objective: In this activity, students will design an experiment demonstrating their understanding of scientific method. Students will predict the effect of resistance on an object.

Materials:

Library tables, melamine, Lexan, or plexiglass "boards" (Beds should be marked with markers appropriate for the surface. Scoring lanes, sides and back can be delineated by masking tape to stop "pennies")
3/4"Washers (5 per student)
Masking tape
Dry wipe and permanent markers
Cornstarch or "baby" powder, mineral oil
Brushes and baby wipes for clean up
Paper, sticky notes (two colors)
Rulers

Procedures:

The question; "What is friction?" will be posed as seatwork for class discussion as students transition from checking books out. Students will discuss the idea quietly at their tables and put their answers on sticky notes. Students from each table will be called on to respond to the question. Students will put their sticky note statements on the Wiki board. The *Friction* exploration activity on Discovery Education will be used to introduce the subject. Students will record questions they may have during the activity to post on the Inquiry board.

I will introduce the game Shove Ha'penny, modeling play and scoring. Students will play a round. Students will be then asked to apply their knowledge of friction with the intent of improving their scores. Students will be prompted by using Think-Aloud questions to write a hypothesis. Components of scientific method will be reviewed. Students will design an experiment and data collection chart to test their theory.

The next class, students will perform their experiment using a “clean” board and noting the distance the washer travels with friction. Students will then apply a lubricant to reduce friction. Students will record their observations and determine average distance with and without lubricant. Team averages will be posted on the interactive white board. Each team will write a summary of their results.

Fifth Grade Velocity and Mass | Activity 2 Marbles

Key Questions: What changes force? (Is there a relationship between velocity and mass?)

In Fifth Grade, students are expected to predict and illustrate the motion of objects in terms of direction and time given or a change in mass or force on the motion of an object. While a change in mass might not increase its speed, it does have an effect on force:

$$F = m * a$$

Therefore a change in mass would be reflected in the magnitude of the force. Acceleration is a change in the rate of velocity and refers to a change in both direction and speed[19], and can be expressed as positive or negative value.

Background:

Marbles are ancient toys, dating as far back as prehistoric times[20]. There are many marble games ranging from target and golf variations, to games of avoidance and capture. The game to which students will be introduced is one that Abraham Lincoln was said to have been adept, Old Bowler.

In this variation[21], a square is drawn on the playing surface and a target marble, known as a “”mib” or a “kimmie”, is placed in each corner. A fifth marble, the “old bowler”, is placed in the center of the square. A “taw line” is drawn a few feet away, behind which all players stand to shoot. The object of the game is to knock the all the mibs out with your shooter, before knocking out the bowler. If the bowler is knocked out before all the mibs, then that player is eliminated from the game and the bowler replaced. When all mibs and the bowler have been knocked out, the game is over. The winner is the player with the most mibs.

Objective: Students will attempt to predict and illustrate the effect of changing mass against stationary targets.

Materials:

5 - $^5/_8$" mibs or kimmies per team
Assorted shooters for each team (≤ 1"Shooters , 1$^3/_8$ " Boulders, 1$^5/_8$" Mammoths, ≥ 2" Toebreakers)
Masking tape or chalk to mark squares and taw line
1 Meter stick or tape measure per team
Chart paper or interactive whiteboard

Procedures:

This activity will be introduced by viewing a video, *The Second Law of Motion*[22]. The key question will be posed to the class. Students will discuss the question. Statements will be recorded on chart paper or the interactive whiteboard. Students will be asked to put their ideas to the test by designing an experiment. The components of scientific method will be reviewed. Students will be asked to form a hypothesis. Students will then work in their teams to design an experiment. Each team will present their ideas and a common set of parameters will be adopted.

The next class, students will be asked to sketch a prediction based on their observations, indicating probable vector and force for both a standard ≤ 1" shooters and a larger one. Students will set up their experiment and play one round with standard shooters and mibs, then record their data. Teams will then play a shooter greater than 1", record the data and then compare it to their prediction.

As a whole group, data will be tabulated. Displacement values will be averaged to determine average velocity. Results for each size of shooter will be compared. Students will discuss the results and determine if a shooter with a greater mass displaced the target mibs further than standard shooters.

Fourth Grade Levers & Force | Activity 3 Chuck-It

Key Question: What changes speed? (How does force affect velocity?)

Background:

The atl-atl, a class-1lever, works by increasing the radius of the wrist turn 6x, which increases the distance of the dart throw.[23] Unlike its more rigid cousin the spear, the atl-atl shaft is thin and flexible and the force of the throw, magnified by the atl-atl is transmitted through the shaft of the atl-atl itself visible in the flight of the dart. There are three classes of levers. Levers that have a fulcrum between the effort and the load are class-1. In Class-2 levers, the load lies between the effort and the fulcrum. Class-3 levers are those in which the load and the fulcrum lie on the ends and force or effort is applied between the two. Atl-atls are class-1, sometimes employing a counterweight as a fulcrum.

Objective: Students will infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel.

Materials / Team:
Tennis ball (a separate color ball for each team)
Chuck-It
Chuck-It Jr.
Measuring tape
Stopwatch
Sidewalk chalk

Video camera (optional)

Procedures:

This activity is a simplified activity based on Lauri Davis' lesson plan, *Investigating the Physics of the Atlatl*. I will review the historical use of the atl-atl and pose the key question and ask how the class might determine the answer. The Big6 research method would be a good process to guide students in thinking about what information they need. The modern atl-atl equivalent would be introduced. Students will discuss how they would measure velocity and write a hypothesis to test. Students will be divided into teams and roles assigned (Launcher, Recorder, Timer and Distance). As a whole group, a data collection table will be developed and procedures explained.

At the starting mark, each team's launcher will throw the ball unaided. The throw would be timed by the time keeper and the displacement measured by another team member. Both time and displacement would be recorded. The launcher would repeat the experiment with the shorter atl-atl, then the longer one. Data would be collected from all teams and discussed as a whole-group activity. If video is taken of the experiment, it will be reviewed this time. Teams would be asked to determine if their experiment verified or disproved their hypothesis based on their inferences from the data.

Fourth Grade Velocity and Mass | Activity 4 Spindles & Tops

Key Question: (How does it do that?) How does potential energy become kinetic energy?

Background:

Spindles are another ancient tool--simply a stick with a weight or whorl--that was developed out of a need to efficiently make cordage, yarn, rope and thread. There are different spindles designed by various cultures to spin local plant and animal fibers. Supported spindles are found in cultures where the fiber was short, while suspended spindles are found in cultures that have access to long staple fibers.[24] Here in the Southeastern United States the bead whorls of spindles used by slaves can still be found in bead shops as well as antique stores.

In essence, a spindle is a long shafted top. It is the shape of the whorl and how the mass is distributed which affects how long the spindle spins. The heavier the mass is, the greater momentum, or tendency to stay in motion, it will have. However, a greater mass will accelerate slowly.

Where the whorl is placed, also has an effect on the duration of the spin, because if the center of mass is low, it is more stable. If the center of the mass is close to the shaft, the spindle will spin faster, while if the mass is on the rim, the rim-weighted spindle will need more force applied (torque) to keep it spinning at the same speed. The classic example of this is the figure-skater who begins spinning with outstretched arms. As she brings her arms close to her body, the speed of her spin increases because the force is the same, but the distribution of mass is different. The manifestation of the force applied to the shaft of the spindle or top appears visibly in the rotation of the whorl, 90° from where the force was applied.

Objective: Students will design, build and test a top that can spin for a long time.

Materials:

1” x 6” dowel lengths (1/team)
$^{1}/_{4}$” x 6” sharpened dowels in various lengths (3/team)
String
Wooden toy wheels, various diameters 3/team
Stopwatch, 1/team

Procedures:

This lesson is based on “On the Ground”, a chapter from Ed Sobey’s book, *Loco-motion: physics models for the classroom.* I will review the historical use of the spindle and post the key question, asking students how they might measure transferred force using another type of spindle, the top. Students will discuss what they know about energy transfer. These notes will be entered as a table that will be inserted in their science notebooks. As a class, an experiment will be designed and a format for recording trial data will be created. Each team will break out to design on paper their three tops based on their knowledge of mass, force and energy. Student logs must include the rationale for each design.

In session 2, students will assemble and test their designs. The class will begin with a review of the dynamics of spindle-motion. They will test each design 3 times and determine the average length of spin for each top. During the last session, students in their teams will summarize their results and present them to the class.

Third Grade Forces and Motion | Activity 5 Nine Pins/Bowling

Key Question: What pushes harder? (What is the relationship between force and mass?**)**

In Third Grade, students return to the concepts of force and motion that they were introduced to in Kindergarten. While the discussion of forces and motion are simply limited to understanding how forces move objects in Kindergarten, 3rd Graders begin to demonstrate their understanding of motion and forces by describing motion in terms of scalar and vector quantities. Scalar measurements describe motion in number value, while vector measurements include both magnitude and direction. Students need to be able to describe their understanding of speed and distance, scalar quantities. Velocity, vector quantity, is not specifically addressed in this grade-level. Third Grade students are also expected to be able to understand that objects are affected by unseen at-a-distance forces such as gravity. Gravity is the force of attraction exerted by all objects, is also part of their curriculum.

Background:

Nine-pins, the precursor of modern-day bowling, is thought to have originated in Germany, played on cinder lanes with pins placed in a diamond formation, however variations appear in both Europe and the U.S. [25] Ball weights and pin sizes varied for centuries, but standardization of oiled[26] wooden plank lanes and technological innovations in the early 20th century changed the physics of the game. Modern bowling balls feature asymmetrical cores covered by polyester, urethane or reactive urethane (resin). [27] The combination of core, cover stock, ball finishes and lane oil affect throw as well as resistance.

Objectives:

Using the KWL research model, students will practice taking notes, then using their notes to write a summary using their inferences, specifically regarding speed or direction resulting from forces acting on an object.

Materials needed:

Traditional Ninepin game
Bowling Pins (one per team)
Balls of varying masses, with similar dimensions (two per team)
Tape measures or meter sticks (one per team)
Tape or poly-dots to mark initial placement of pin

Procedure:

This Information Skills lesson begins with students reviewing their knowledge of forces, which had been introduced in the homeroom, with a modified KWL activity, an example of which is appended). If the subject has not been introduced in the homeroom, as is sometimes the case when co-teaching with an entire grade-level, *Forces Make Things Move* by Kimberly Brubaker Bradley read aloud is a good introduction. As students seat themselves after checking out their books, their seatwork is to silently write their review in the "Know" section of their KWL chart. When the class has assembled, students will be allowed to discuss forces at their table. Finally, as a whole group, the class completes the "Know" portion of the KWL chart on chart paper or interactive whiteboard. Using a selection of balls with similar dimensions, but of varying weight and a bowling pin, the question of which ball would deliver more force would be posed. Students will be encouraged to hypothesize and student-generated questions will be added to the "Would like to know" section of the chart. A copy of this chart should be sent to the homeroom teacher. An alternative to this assignment if there is time would be to create a split cover "matchbook" style foldable with examples of both push and pull forces.

The next session begins with a review of the concepts of forces, mass, distance, direction and displacement. Students are expected to measure the displacement of the pin, not the distance of path of travel. The balls are weighed and those weights being recorded in the "Know" section of the KWL chart. The teacher reviews behavior expectations as well as procedures for recording data and assigns roles within the teams. Each team of students selects two balls for testing and records those weights in the "Know" portion of their KWL chart. Students split into teams and perform the experiment, measuring the displacement of the bowling pin after knocking it over with balls of differing masses. Each team will return to their table and discuss their results. The teacher will tabulate data collected on whiteboard or chart paper, a copy of which will be sent to the homeroom.

The final session of this lesson begins with a review of the data collected by the class. As a whole-group, students will discuss data and make inferences. Teacher will model using actual data collected and inference statements to write a summary. Students will practice writing their own summary based on their data and their inference statements.

Returning once again to Best Practices

In the end, these lessons must reflect the best practices for teaching both science and information skills. There must be engagement of the students with a relevant research question. Students should be able to select a research model appropriate for the topic. Students should devote time to researching the background and the teacher needs to provide time for students to contemplate and process the new information. A portion of the lesson should be a hands-on activity that also has a method for them to record their observations graphically and/or mathematically. Learning, we know, is a social activity. So, there needs to be time for processing through discussion and writing. While instructors can do an assessment, perhaps the best assessment of the work comes from the students themselves as they apply what they just learned—in this case, by improving their game.

Worksheets for Activities

Chuck-It Log

Team:______________Homeroom Teacher____________________________Date_________

Launcher____

Timer____

Distance____

Recorder____

Hypothesis:____

____

Mass of ball:__________________

Your data	Meters / Seconds
No atl-atl	
Chuck-It Jr	
Chuck-It	

Raw Data for teams

	Red	Orange	Yellow	Green	Blue	Purple
No lever						
Chuck-It Jr						
Chuck-It						

Summary:____

____

Conclusion based on inferences:____

Marbles Log

Team_________Homeroom Teacher:___________________________Date:_________

Hypothesis:____

On a sheet of graph paper, sketch the Bowler square and taw line using a blackpencil. Based on your experience predict the probable path and distance of a standard shooter and a non-standard shooter using a blue pencil. After your shot, draw the displacement using an orange pencil.

Standard Shooter / Team Members							Team Average
Distance of displacement							

Boulder / Team Members							Team Average
Distance of displacement							

Mammoth							Team

Team Members							Average
Distance of displacement							

Toebreaker / Team Members							Team Average
Distance of displacement							

Summary of results:____

____

Conclusion based on inferences:____

____

Shove Ha'Penny Log

Team__________Homeroom Teacher:______________________________Date:__________

Hypothesis:____

____

Your Name:	Penny 1	Penny 2	Penny 3	Penny 4	Penny 5	Average
Distance of displacement on clean board						
Distance of displacement with________________						

Team Averages	Name:	Name:	Name:	Name:	Name:	Name:
Distance of displacement on clean board						
Distance of displacement with________________						

Summary of results:____

____

Conclusion based on inferences:____

____

____

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Resources for Students

Bonnet, Robert L., and Dan Keen. *Home run!: science projects with baseball and softball*. Berkeley Heights, NJ: Enslow Publishers, 2010. Print.

Part of the middle-school Enslow Publishing series on the science in sports, mostly physics. This set is worth purchasing because it would appeal to a wide range of students. Also includes:

Gardner, Robert, and Dennis Shortelle. *Slam dunk! science projects with basketball* . Berkeley Heights, NJ: Enslow Publishers, 2010. Print.

Goodstein, Madeline P.. *Wheels! science projects with bicycles, skateboards, and skates* . Berkeley Heights, NJ: Enslow Publishers, 2010. Print.

Goodstein, Madeline P.. *Goal!: science projects with soccer*. Berkeley Heights, NJ: Enslow Publishers, 2010. Print.

Claybourne, Anna. *The science of a guitar: the science of sound*. North American ed., U.S. ed. Pleasantville, NY: Gareth Stevens Pub., 2009. Print.

A nice addition to the upper elementary or middle-school collection.

Hammond, Richard. *Car science* . New York: DK Pub., 2008. Print.

This covers energy, friction, speed and even explains some of the technology behind racecars.

Hollihan, Kerrie Logan. *Isaac Newton and physics for kids: his life and ideas with 21 activities*. Chicago, Ill.: Chicago Review Press, 2009. Print.

Part of a series about the lives of scientists. Contains a short biography and activities. Set also includes:

Herbert, Janis. *Leonardo da Vinci for kids: his life and ideas : 21 activities*. Chicago, Ill.: Chicago Review Press, 1998. Print.

Panchyk, Richard. *Galileo for kids: his life and ideas*. Chicago, Ill.: Chicago Review Press, 2005. Print.

Lemke, Donald B., Thomas K. Adamson, Tod Smith, and Bill Anderson. *Lessons in science safety with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2007. Print.

Part of the popular Capstone Press science series featuring an African –American male protagonist in a graphic novel format. The information is provided imbedded in short adventures that appeal to a wide audience. Some of the titles are also available in e-book format so students can read them online or teachers can use them on interactive whiteboards. Subjects range from Earth Science, to Biology, to Physics. Some of the other titles in this series include:

Donnell, Liam, Richard Dominguez, and Charles Barnett. *The shocking world of electricity with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2007. Print

Gianopoulos, Andrea, Cynthia Martin, and Barbara Jo Schulz. *The attractive story of magnetism with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2008. Print.

Sohn, Emily, Cynthia Martin, and Anne Timmons. *Adventures in sound with Max Axiom, super scientist* . Mankato, Minn.: Capstone Press, 2007. Print.

Sohn, Emily, Steve Erwin, and Charles Barnett. *A crash course in forces and motion with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2007. Print.

Sohn, Emily, and Nick Derington. *The illuminating world of light with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2008. Print.

Sandvold, Lynnette Brent, and Barbara Bakowski. *Superhero science: kapow! comic book crime fighters put physics to the test*. Pleasantville, NY: Gareth Stevens Pub., 2010. Print.

The characters should appeal to students, but I would recommend this as a secondary purchase, preferring the Max Axiom series listed above.

Sayre, April Pulley. *Secrets of sound: studying the calls and songs of whales, elephants, and birds*. Boston: Houghton Mifflin, 2002. Print.

April Sayer does it again. This is a thoughtful exploration of the work of scientists in the field. For the student who wants to know how science is applied in the real world.

Resources for Teachers

"A Periodic Table of Visualization Methods." *Visual Literacy: An E-Learning Tutorial on Visualization for Communication, Engineering and Business*. N.p., n.d. Web. 25 Nov. 2011. <http://www.visual-literacy.org/periodic_table/periodic_table.html>.

A quick, go-to reference list of visual literacy methods for teaching. For more in-depth information see Kellie Marcarelli's *Teaching science with interactive notebooks* or Steve Moline's *I see what you mean: children at work with visual information*.

"Atlatl History and Physics." *Web Pages of Kevin A. Geiselman*. N.p., n.d. Web. 19 May 2011. <http://www.tasigh.org/ingenium/atlatl.html>.

The webpage is short explanation of the physics that make atl-atls work.

Bailey, Abigail. "Choosing a Spindle and the Physics of Handspinning - How Spindle Weight is Important." *EzineArticles Submission - Submit Your Best Quality Original Articles For Massive Exposure, Ezine Publishers Get 25 Free Article Reprints*. N.p., n.d. Web. 28 Oct. 2011. <http://ezinearticles.com/?Choosing-a-Spindle-and-the-Physics-of-Handspinning---How-Spindle-Weight-is-Important&id=4023869>.

This web-article is a short explanation of spindle weight and distribution. For more information see Abby Franquemont's *Respect the spindle: spin infinite yarns with one amazing tool*.

Davis, Lauri. "Investigating the Physics of the Atlatl." *Mississippi Valley Archaeology Center*. Mississippi Valley Archaeology Center at the University of Wisconsin - La Crosse, n.d. Web. 11 Nov. 2011. <www.uwlax.edu/mvac/PDFFiles/NEH2010Les/Atlatl.pdf>.

A nicely written lesson plan for middle school science on atl-atl physics.

Franquemont, Abby. "The Science of Spindles." *Respect the spindle: spin infinite yarns with one amazing tool*. Loveland, CO: Interweave Press, 2009. 23-36. Print.

Written for the serious fiber spinner who wants to improve their thread, this explains both spindle and wheel spinning. Franquemont's book is more accessible than Alden Amos' *Spinning Wheel Primer*.

Fulwiler, Betsy Rupp. *Writing in science: how to scaffold instruction to support learning*. Portsmouth, NH: Heinemann, 2007. Print.

Fulwiler's book discusses the importance of writing in the teaching of science.

"Get in the Fold!: The Forces That Move Us." *Get in the Fold!*. N.p., n.d. Web. 25 Nov. 2011. <http://getinthefold.blogspot.com/2011/08/forces-that-move-us.html>.

A quick review of foldables that can be used to teach a variety of subjects.

Hewitt, Paul G.. *Conceptual physics*. 8th ed. Reading, Mass.: Addison Wesley, 1998. Print.

If you have to buy a basic physics textbook, this is the one. You don't because The Physics Classroom is online, but if you have to have a book to hold, look for this one in used textbook stores online.

Jeremy, Roberts. "Atlatl Video Documentary - Atlatl.com - A Five Minute Video by Jeremy Roberts on Atlatls Staring Atlatl Bob - Atlatl and Dart Primitive Weapon Systems by BPS Engineering." *Precision Atlatl & Dart Systems - Atlatl.com - Atlatl Bob - Maker of Authentic Atlatl Systems*. atlatl.com, n.d. Web. 15 June 2011. <http://www.atlatl.com/atlatlvideo.php>.

William Perkin's tongue-in-cheek explanation of the history and physics atl-atl. Do not show this to your students without previewing it!

Keeley, Page, and Rand Harrington. *45 new force and motion assessment probes*. Arlington, Va.: NSTA Press, 2010. Print.

Inquiry based lessons that begin with a question. Ready-to-use lessons, complete with worksheets.

Lemke, Donald B., Thomas K. Adamson, Tod Smith, and Bill Anderson. *Lessons in science safety with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2007. Print.

Part of the popular Capstone Press science series featuring an African –American male protagonist in a graphic novel format. The information is provided imbedded in short adventures that appeal to a wide audience. Some of the titles are also available in e-book format so students can read them online or teachers can use them on interactive whiteboards. Subjects range from Earth Science, to Biology, to Physics. Some of the other titles in this series include:

Donnell, Liam, Richard Dominguez, and Charles Barnett. *The shocking world of electricity with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2007. Print

Gianopoulos, Andrea, Cynthia Martin, and Barbara Jo Schulz. *The attractive story of magnetism with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2008. Print.

Sohn, Emily, Cynthia Martin, and Anne Timmons. *Adventures in sound with Max Axiom, super scientist* . Mankato, Minn.: Capstone Press, 2007. Print.

Sohn, Emily, Steve Erwin, and Charles Barnett. *A crash course in forces and motion with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2007. Print.

Sohn, Emily, and Nick Derington. *The illuminating world of light with Max Axiom, super scientist*. Mankato, Minn.: Capstone Press, 2008. Print.

Marcarelli, Kellie. *Teaching science with interactive notebooks*. Thousand Oaks, Calif.: Corwin Press, 2010. Print.

This book covers the how-to lessons of creating the science notebook. Pair this book with Betsy Rupp Fulwiler's Writing in science: how to scaffold instruction to support learning for both the rationale and practical application.

Moline, Steve. *I see what you mean: children at work with visual information*. York, Me.: Stenhouse Publishers, 1995. Print.

I saw the electronic preview of this, and was impressed. Although I have not actually used this, I plan to buy it to supplement Marcarelli and Fuwiler's texts.

"PhET Simulations Elementary." *Physics Department*. University of Colorado Boulder, n.d. Web. 3 Nov. 2011. <hhttp://phet.colorado.edu/en/simulations/category/by-level/elementary-school>.

Physics animations that are perfect to show on an interactive whiteboard or to assign to students. Divided by concept as well as grade-level.

"Slow Motion Atlatl - YouTube Paleoplanet.net." *YouTube - Broadcast Yourself.* . N.p., n.d. Web. 20 Nov. 2011. <http://www.youtube.com/watch?v=PCRiuaKQ1dE&feature=colike>.

This is the atl-atl video to show to students. Wordless B&W footage is nicely edited.

Sobey, Ed. *Loco-Motion: Physics Models for the Classroom*. Chigago, Illinois: Zephyr Press, 2005. Print.

Another great go-to Physics lesson plan book, with ready-made lessons and worksheets.

Vasquez, Jo Anne, Michael W. Comer, and Frankie Troutman. *Developing visual literacy in science, K-8*. Arlington, VA: NSTA Press, National Science Teachers Association, 2010. Print.

This book explains the importance of teaching visual literacy, which Media Specialists already know, but it is nice to have confirmation from a regular “classroom” teacher. Pair this one with Marcarelli, Moline, Fulwiler and you will have a nice “How-to” professional development series on integrating research, writing, art and science.