TALKING AND WRITING TO LEARN: THE PHYSICS OF TRAFFIC INTERSECTION SAFETY, PART TWO

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Part Two of this lesson further develops students' literacy skills in the areas of critical reading and writing. Students apply their scientific knowledge and basic argumentation skills to determine the safety of a single traffic intersection. Students learn how to critically read scholarly journal articles and construct a formal written argument. Students will broaden the scope of their argument from a single intersection to the best practices for enforcement of traffic laws. Moving past emotionally-charged opinions, students use scientific evidence to inform and establish an evidence-based position on the use of cameras to impact the behavior of motorists.

The first part of the unit (Perkins Coppola, 2018) introduced students to a method of mathematical modeling and local data to make a decision on the safety of a specific traffic intersection. The second part of the unit builds on this interest in local traffic to address a larger question of traffic law enforcement. There is no single model or data set that unequivocally answers the question of whether traffic cameras and tickets should be used to enforce the law. The objective for the second part is for students to analyze multiple documents in order to construct a fact-based position on the use of technology to police traffic. Students engage the issue as informed citizens, participating in authentic decision-making through the preparation of a formal argumentation paper. Several reading and writing strategies are incorporated into the scaffolding of the paper, providing a strong integration of science with English language arts. The argumentation paper may be adapted for use in any locale, but was written here to demonstrate how it was implemented in an Indiana classroom.

The approach I used to prepare students to construct an argument was informed primarily by two sources. The second edition of Douglas Lewellyn's "Teaching High School Science Through Inquiry and Argumentation" (2012) provided the structure for writing the argumentation paper. Lewellyn proposed a well-structured argument is composed of five parts: (1) question, (2) claim, (3) evidence, (4) explanation, and (5) rebuttal. In this lesson, I introduced the question in the Engage phase.

The question, proposed by the teacher or the student, serves to guide and focus the students' scientific investigation of a phenomenon. The question may be an open-ended pursuit of a yet unexplained relationship or serve to challenge students to take a position on a provided explanation. Students may reason deductively, beginning with a claim in mind and pursuing observational and experimental evidence to support it. Or students may reason inductively by collecting observational and experimental evidence to use in distilling a formal claim. The explanation brings the claim and evidence together using established scientific principles to draw conclusions. The rebuttal serves to expose possible counterclaims and explain how the evidence can be used to dismiss their validity.

The second source I used to inform the design of this lesson is the Argument-Driven Inquiry model (Sampson, Grooms, & Walker, 2009). The lesson I taught could be recast in the eight stages of the argument-driven inquiry instructional model, but I chose instead to borrow and modify Stages 3 and 4 to serve as the Explain phase, in which students analyzed data, developed a tentative argument, shared the argument through whiteboarding, and then gave and received feedback. This method of peer review gave students a chance to draft and deepen their positions prior to engaging in the argumentative writing exercise.

This second unit was structured using the 5E instructional model and primarily involved two NGSS Practices: (7) Engaging in argument from evidence and (8) Obtaining, evaluating, and communicating information.

Engage (30 minutes)

Students were provided three news articles from the local media (Appendix A). The articles were part of the media coverage of debate in the state legislature over the legal status of traffic cameras during the general session. I asked students to read the articles and use two reading strategies as they go. The first was a text marking strategy in which the students numbered each paragraph, circled key words and names, and underlined significant claims (Florida Department of Education, n.d.). The second strategy involved using sticky notes to create a place on the page for students to jot down reactions, questions, and connections made as they read each article (Daniels & Zemelman, 2014). Highlighters were also provided for students who preferred to mark text this way (Yue, Storm, Kornell, & Bjork, 2015).

After students read the articles, I posted a short writing prompt asking them to give their personal opinions on the use of traffic cameras in Indiana. As students read their opinions aloud to the whole class, I compiled a list of their thoughts on the whiteboard in a T-chart. One side of the chart was in support of traffic cameras. The other side was for opinions in opposition to their use. In my experience, the opinions of the class were split equally. Some students were dismissive and skeptical, expressing concern that the cameras only served to generate revenue from traffic passing through town. Others were defensive and supportive, claiming something had to be done and that the cameras freed up law enforcement personnel to handle more important matters.

Explore (1 day of class + 2 days to complete at home)

After providing time for personal opinions to be expressed, I introduced the argumentation assignment to the class. I posed the guiding question to the students: "Should technology such as red light cameras and speed cameras be used to police traffic?" I framed the lessons as an opportunity to serve as citizens who were providing much needed information to local lawmakers working in committee to draft new legislation. Rather than sharing their initial opinions, I persuaded them to use their understanding of physics and their skills as researchers to draw an

evidenced-based conclusion from a structured review of several journal articles published in the professional literature. A list of articles from professional engineers and scientists who study traffic was provided in Appendix B. These scholarly studies used data such as the rate of traffic accidents and field studies of driver behavior to support their positions on the effectiveness of traffic cameras in various locations and situations. Some articles investigated whether red light cameras caused more accidents than they prevented, while others focused on how well speed cameras altered the behavior of motorists.

I passed out 4-6 printed articles for groups of students to review. I provided a brief introduction to the general outline of a scientific paper and reminded students to use their text marking skills to assist them in digesting the readings. I also introduced them to methods of text coding (Florida Department of Education, n.d.), which used symbols written in the margins to help students quickly notate their reactions to the reading. A list of these was found at http://www.fldoe.org/core/fileparse.php/16294/urlt/912TC.pdf. I provided note cards for students to use to write down and organize key pieces of information to include in their final papers. I also encouraged the students to supplement the articles by conducting an Internet search for other perspectives on the traffic cameras and carefully reminded them to consider their sources' scholarly value before citing. At the end of the class I provided time for the students to share their information with the members of their group. Students continued their evaluation of the articles at home, taking notes to use in the next phase of the lesson.

A couple of alternative ideas for this section of the lesson included having the students produce an annotated bibliography. Each journal is cited and then a brief summary of the main points of the article is provided. The benefit of producing an annotated bibliography is that the students were forced to consider each article individually and evaluate each source independently. A second alternative idea for this section was to have students annotate directly digital copies of the article. Tablet computers allow students to conduct text marking on PDF versions of the documents

and then share these directly with other students. Significant sections of text can be copied into an open document and catalogued for inclusion in a later paper, speeding up the process of producing quotes and serving as a more portable method of saving and collecting student work. Online resources such as Perusall allowed teachers to view student annotations and allowed groups to share annotations with each other as they worked.

Explain (2 days of class)

After students completed their independent annotations of the provided articles and concluded their initial search for other reference sources, we transitioned into the Explain phase of the lesson. In groups, students were provided a whiteboard and asked to divide it into four sections: (1) The guiding question; (2) Our claim; (3) Our evidence; and (4) Our justification of the evidence. The whiteboard was useful because students could erase and adjust quickly and cleanly. Each group spent a full class period organizing their collective notes, deciding on a claim, and deciding what evidence from their text resources best supported the claim. I encouraged the students to provide empirical data from the studies in the evidence section and provide proper citations to the articles. In the justification section, the group explained why they believed their claim and supporting evidence were the most important and significant out of all the resources they examined. At the conclusion of the first day, each group took a digital photo of their whiteboard and submitted it to me via email.

I began the next class by explaining that each group would present their whiteboard to the class through a gallery walk and then introduced some criteria for providing constructive feedback to each group. I passed out a different color of Post-It notes to each group. I explained that feedback should be limited to four types: (1) We like this because ___; (2) Will you clarify ___?; (3) We suggest that you add ___; and (4) We suggest you change this to ___. One person from the group stayed at the whiteboard to present. The rest of the group went together to hear a presentation from another group in the class. The presenter was given three minutes to share their argument, followed by two

minutes of questions from their audience. An additional two minutes was given so the audience can write on the Post-It notes before rotating to the next presentation, for a total of seven minutes. After two rotations, the presenters rotated back into the groups in order to give everyone a chance to present and to ask questions.

After the final rotation, I asked each group to address the feedback they received on the notes. Each person in the group summarized one of the four types of feedback received and submitted it to me and to the rest of the group electronically.

Elaborate (30 minutes + 1 week outside class)

Working within the groups, each student had many opportunities to express and defend their position on the guiding question. I challenged students to draw from these experiences in order to come to a final position on the use of technology to police traffic and to express this position in a structured argumentative paper.

I introduced Lewellyn's five parts to a well-structured argument, describing each part in detail and providing examples of each. I then provided them with an outline for the paper (Appendix C). The outline divided the paper into six sections: (1) Introduction; (2) Argument 1 (3) Argument 2; (4) Argument 3; (5) Refutation; and (6) Conclusion. Each of the arguments was composed of a claim, supporting evidence, and an explanation of how the evidence supported the claim. I spent a couple minutes discussing the difference between evidence and opinion with the whole class, noting that evidence required observational or experimental investigation. Then I gave students ten minutes in class to begin filling out the rough outline, followed by five minutes to share with a partner. I provided reading materials and sentence starters (Goonen & Pittman, 2014; Pang, n.d.) for reference resources to help them develop their writing.

I provided a detailed rubric (Appendix D) to my students that explains how I will be grading their papers. The rubric clarifies my emphasis on the use of evidence to support each of the claims. At least three unique claims must be provided, each supported by evidence found in the articles and

data sources the students obtain. At least two scholarly sources and two media sources must be referenced in the paper. I further clarified that there was no "right" position to take, but that each argument would be evaluated on the strength of the evidence and explanations used to support each claim.

Evaluate (1 class period)

Before students submitted their individual argumentation papers, I set aside one class period for students to provide feedback to one another. Students worked in groups of three to read each other's papers and score with the rubric I provided. I made Post-It notes available again and asked student feedback to be limited to the four types we used to evaluate the whiteboards. The final papers were submitted to me two days later, giving each writer ample time to revise and refine their arguments as necessary.

Conclusion

The study of traffic intersections provided an excellent opportunity to apply the kinematics equations to something other than projectiles and falling objects. High school is the time when students transition from passengers in vehicles to responsible drivers. It made sense to use the science classroom to inform their decision making as they learn to respect the road and the laws that govern it. High school is also the time when students gain their first opportunity to exercise their citizenship through voting and the political process. This lesson helped them to develop the skills to research thoughtfully before taking a position on an issue. The intersection of citizenship, mathematical modeling, and argumentation in this unit demonstrated the power and significance of connecting science, literacy, and writing within a real world context.

References

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Table 1: Lesson Alignment to Indiana Standards (2016)			
Integrated Chemistry & Physics Standards (IDOE)	AP Physics 1 Standards (IDOE)	Science and Engineering Process Standards (IDOE)	Literacy in Science/Technical Subject standards (IDOE)
ICP.1.1 Develop graphical, mathematical, and pictorial representations (such as a motion map) that describe the relationship between the clock reading (time) and position of an object moving at a constant velocity and apply those representations to qualitatively and quantitatively describe the motion of an object. **ICP.1.4** Distinguish between the terms "speed," "velocity," "average speed," and "average velocity" and determine the value of any of these measurements given either a graphical or mathematical representation. **ICP 2.1** Develop graphical, mathematical, and pictorial representations (such as a motion map) that describe the relationship between the clock reading (time) and velocity of an object moving at a constant acceleration and apply those representations to qualitatively and quantitatively describe the motion of an object in terms of its change in position or velocity.	**PI.1.1** Develop graphical, mathematical, and pictorial representations (e.g. a motion map) that describe the relationship between the clock reading (time) and position of an object moving at a uniform rate and apply those representations to qualitatively and quantitatively describe the motion of an object. **PI.1.4** Describe the differences between the terms "distance," "displacement," "speed," "velocity," "average speed," and "average velocity" and be able to calculate any of those values given an object moving at a single constant velocity or with different constant velocities over a given time interval. **PI.2.1** Develop graphical, mathematical and pictorial representations (e.g. a motion map) that describe the relationship between the clock reading (time) and velocity of an object moving at a uniformly changing rate and apply those representations to qualitatively and quantitatively describe the motion of an object.	**SEPS.2** Developing and using models and tools **SEPS.4** Analyzing and interpreting data **SEPS.5** Using mathematics and computational thinking **SEPS.7** Engaging in argument from evidence **SEPS.8** Obtaining, evaluating, and communicating information	**11-12.LST.5.1:** Write arguments focused on discipline-specific content. **11-12.LST.7.1** Conduct short as well as more sustained research assignments and tasks to answer a question (including a self-generated question), test a hypothesis, or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **11-12.LST.7.2:** Gather relevant information from multiple types of authoritative sources, using advanced searches effectively; annotate sources; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; synthesize and integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation (e.g., APA or CSE).

			11-12.LST.7.3: Draw evidence from informational texts to support analysis, reflection, and research.

Appendix A: Suggested Articles for Indiana Classrooms

Kehoe, T. (2015, February 26). *Speed camera proposal hits red light at statehouse.* Retrieved from http://wthitv.com/2015/02/26/speedcamerapproposalhitsredlightatstatehouse.

Kehoe, T. (2015, February 16). *Indiana to consider giving green light to speed cameras.* Retrieved from http://wishtv.com/2015/02/16/indiana-to-consider-giving-green-light-to-speed-cameras.

Tuohy, J. (2015, February 18). In a snap, camera speeding bill breezes through committee. *Indianapolis Star.* Retrieved from http://www.indystar.com/story/news/2015/02/18/smile-just-got-caught-speeding/23584003.

Appendix B: Suggested Readings on Ticket Cameras

Red Light Cameras - Reports

Aeron-Thomas, A., & Hess, S. (2005). Red-light cameras for the prevention of road traffic crashes. *The Cochrane Library*.

Cohn, E., Kakar, S., & Farrington, D. (2015). Red Light Camera Interventions for Reducing Traffic Violations and Accidents: A Systematic Review.

Council, F., Persaud, B., Eccles, K., Lyon, C., & Griffith, M. (2005). *Safety evaluation of red-light cameras: executive summary. Report no*. FHWA HRT-05-049. Washington, DC: Federal Highway Administration.

Wilson, C., Willis, C., Hendrikz, J. K., & Bellamy, N. (2006). Speed enforcement detection devices for preventing road traffic injuries. *The Cochrane Library*.

Red Light Cameras - Studies

Erke, A. (2009). Red light for red-light cameras?: A meta-analysis of the effects of red-light cameras on crashes. *Accident Analysis & Prevention*,*41*(5), 897-905.

Høye, A. (2013). Still red light for red light cameras? An update. *Accident Analysis & Prevention*, *55*, 77-89.

Hu, W., McCartt, A. T., & Teoh, E. R. (2011). Effects of red light camera enforcement on fatal crashes in large US cities. *Journal of safety research*,*42*(4), 277-282.

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Shin, K., & Washington, S. (2007). The impact of red light cameras on safety in Arizona. *Accident Analysis & Prevention*, *39*(6), 1212-1221.

Thomas, L., Srinivasan, R., Decina, L., & Staplin, L. (2008). Safety effects of automated speed enforcement programs: Critical review of international literature. *Transportation Research Record: Journal of the Transportation Research Board*, (2078), 117-126.

Wong, T. (2014). Lights, camera, legal action! The effectiveness of red light cameras on collisions in Los Angeles. *Transportation research part A: policy and practice*, *69*, 165-182.

Yang, Q., Han, L. D., & Cherry, C. R. (2013). Some measures for sustaining red-light camera programs and their negative impacts. *Transport policy*, *29*, 192-198.

Speed Cameras & Kangaroo Driving (drivers brake before and accelerate after speed cameras)

De Pauw, E., Daniels, S., Brijs, T., Hermans, E., & Wets, G. (2014). An evaluation of the traffic safety effect of fixed speed cameras. *Safety science*, *62*, 168-174.

De Pauw, E., Daniels, S., Brijs, T., Hermans, E., & Wets, G. (2014). To brake or to accelerate? Safety effects of combined speed and red light cameras. *Journal of safety research*, *50*, 59-65.

Marciano, H., & Norman, J. (2015). Overt vs. covert speed cameras in combination with delayed vs. immediate feedback to the offender. *Accident Analysis & Prevention*, *79*, 231-240.

Pérez, K., Mari-Dell'Olmo, M., Tobias, A., & Borrell, C. (2007). Reducing road traffic injuries: Effectiveness of speed cameras in an urban setting. *American Journal of Public Health, 97*(9), 1632-1637.

Pilkington, P., & Kinra, S. (2005). Effectiveness of speed cameras in preventing road traffic collisions and related casualties: systematic review. *BMJ*, *330*(7487), 331-334.

Wilson, C., Willis, C., Hendrikz, J. K., Le Brocque, R., & Bellamy, N. (2010). Speed cameras for the prevention of road traffic injuries and deaths. *The Cochrane Library*.

Wong, T. (2014). Lights, camera, legal action! The effectiveness of red light cameras on collisions in Los Angeles. *Transportation research part A: policy and practice*, *69*, 165-182.

Both Speed and Red Light Cameras

De Pauw, E., Daniels, S., Brijs, T., Hermans, E., & Wets, G. (2014). To brake or to accelerate? Safety effects of combined speed and red light cameras. *Journal of safety research*, *50*, 59-65.

Consequences of Removing Existing Red Light Cameras

Porter, B. E., Johnson, K. L., & Bland, J. F. (2013). Turning off the cameras: Red light running characteristics and rates after photo enforcement legislation expired. *Accident Analysis & Prevention*, *50*, 1104-1111.

Appendix C: Outline for argumentation paper

I. Introduction
   a. Guiding question
   b. Explain the relevance
   c. Thesis statement (Position)

II. Argument #1
   a. Claim #1
   b. Evidence supporting claim
   c. Explanation as to how the evidence supports the claim

III. Argument #2
   a. Claim #2
   b. Evidence supporting claim
   c. Explanation as to how the evidence supports the claim

IV. Argument #3
   a. Claim #3
   b. Evidence supporting claim
   c. Explanation as to how the evidence supports the claim

V. Refutation
   a. Counterclaim
   b. Explanation of counterclaim
   c. Refutation of counterclaim

VI. Conclusion
   a. Restate the thesis
   b. Summarize the arguments

Appendix D: Rubric for grading argumentation papers

	Meets Expectations	Needs Improvement	Inadequate
Scholarly sources	Position paper shows evidence that the minimum number of required scholarly studies was met or exceeded. Evidence includes specific citation of the articles in the body of the paper and integrated into the argument and/or counterargument in significant ways.	Less than the minimum number of required number of sources were used in the position paper in meaningful ways or were not properly cited.	One or no articles were used in the position paper.
Structure	Position paper follows the required structure as provided in the graphic organizer for writing an argumentation paper (Claims, three or more reasons, evidence, counterclaims, refutation of counterclaims, conclusion)	Paper is loosely based on the required structure but is missing	Paper failed overall to follow the required structure in any reasonable manner.
Claim	Claim is clearly stated, hooks the reader, and establishes a clear direction for the position paper addressing the predetermined topic of traffic intersection cameras.	Claim is stated but fails to hook the reader or establish a clear direction for the position paper.	No claim is established in the introductory paragraph or claim is unrelated to use of traffic intersection cameras to regulate drivers.
Reasons	Three or more reasons are provided, introduced in a logical order. All reasons are fact-based rather than personal opinions.	Two reasons are provided or reasons fail to be introduced in a logical order. Some reasons are based on opinion.	One reason is provided or provided reasons are based solely on opinion.
Evidence	More than one piece of evidence is provided to support each reason. Evidence is relevant, accurate, demonstrates an understanding of the topic, and comes from credible sources.	One reason is supported by a single piece of evidence. Quality of evidence used does not meet aforementioned standards.	Two or more reasons are supported by a single piece of evidence or a reason fails to be supported by any evidence. Opinions are used in place of evidence.
Counterclaim and Refutation	Establishes the other side of the argument clearly. Refutes using facts or examples rather than personal opinions.	Counterclaim is established without a refutation or counterclaim is poorly established.	No discussion of counterclaims or refutation is included
Conclusion	Conclusion supports the presented argument by following from the reasons and evidence provided in the body of the paper.	Conclusion fails to draw the reasons and evidence together in a manner that solidifies the claim.	No conclusion is drawn (missing) or the conclusion fails to draw the elements of the writing together in any discernable manner.
Quality	Paper exceeds expectations for writing quality and is genuinely persuasive in nature.	Paper meets expectations for writing quality and establishes the author's position.	Paper fails to meet expectations for writing quality or fails to use fact to persuade the reader.