

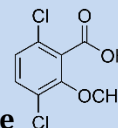
3D-Student Science Performance

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Grade: 10-12 Integrated Chemistry

Lesson Title

Lesson Topics: Matter and Chemical Reactions, Energy Flow, Designing Solutions and Carrying Out Investigations. THIS IS A MULTI-DAY LESSON!



The Great Dicamba Debate

Lesson Performance Expectations (Standard) from State Standards or NGSS:

CI-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. [AR Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reactions systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.][Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time and does not include calculating Eq constants and concentrations].

CI1-ETS1-2: Design a solution to a complex real world problem by breaking it down into small, more manageable problems that can be solved through engineering. [AR Clarification Statement: Examples of real-world problems could include wastewater treatment, production of biofuels, and the impact of heavy metals or phosphate pollutants on the environment.]

CI-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. [AR Clarification Statement: This PE is fully addressed in this course. Emphasis is on the impacts of human activities on physical systems. Examples of data on the impacts of human activities could include the quantities and types of pollutants released (fertilizer, surface mining, and nuclear by-products). Examples for limiting future impacts could range from local efforts (reducing, reusing, and recycling resources) to large scale engineering design solutions (nuclear power, photovoltaic cells, wind power, and water power.)

CI3-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. [AR Clarification Statement: Examples of the applications could include renewable energy resources (solar cells and wind farms), the Haber process for production of fertilizer, and increased fuel efficiency of combustion engines.]

CCSS Connections:

Reading:

Connections to the Arkansas Disciplinary Literacy Standards:

WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection and research.

WHST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media in

order to address a question or solve a problem.

Connections to the Arkansas English Language Arts Standards:

SL.11-12.5: Make strategic use of digital media in presentations to enhance understanding of findings, reasoning, and evidence and add interest.

Math:

MP.2: Reason abstractly and quantitatively.

MP.4: Model with mathematics.

HSN.Q.A.1-3: Use units as a way to understand problems, and to guide the solution of multi-step problems; choose and interpret units consistently, choose and interpret the scale and origin in graphs and data displays. Define appropriate quantities for descriptive modeling. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Lesson Performance Expectations:

- Students will be able to research a current event issue (the use of Dicamba in soybean and other fields).
- Students will use critical thinking to make an informed decision in regards to Dicamba usage, keeping in mind Le Chatelier’s principal and its effect on the herbicide, human impact, Dicamba’s effect on local farmers, and the need globally for a cheaper, easily managed protein source.
- Students will then debate the reason for their decision in a town hall meeting session

Elicit:	Student Science Performance
<p>Implement a graphic organizer with students about what they know about farming in Arkansas. How is farming done today? Do the students know any farmers? What crops are grown in Arkansas and why is farming important? Ask students how farmers manage crops (what do they</p>	<p>Phenomenon: Due to increasing demand for higher food production, herbicides like Dicamba are used on commercial crops to kill highly invasive weeds. Unfortunately, Dicamba also causes increased resistant strains and can damage nearby sensitive crops. It also favors growing GMO crops that are resistant to Dicamba.</p> <p>Gather:</p> <ol style="list-style-type: none"> 1. <i>Students develop questions and obtain information about the stakeholder they have procured.</i> 2. <i>Students obtain information about Dicamba usage as it pertains to the stakeholder they are representing.</i> <p>Teaching suggestion: There are several websites students can refer to for learning about their position. Here are just a few:*</p>

<p>do to curtail weeds and pests) and why is this an essential part of farming? How exactly do herbicides chemically affect weeds? What are some advantages to chemical management of weeds and pests in farming? What are some drawbacks to chemical management of weeds and pests in farming?</p> <p>Engage:</p> <p>Tell the students they will be participating in a town hall session involving the use of the herbicide Dicamba. Each student group will be given a 'stakeholder' in the Dicamba concern and their job will be to defend the stakeholder position they received.</p> <p>Explore:</p> <p>Ask the students</p>	<p>http://scholarworks.uark.edu/cgi/viewcontent.cgi?article=1608&context=etd Covers Pigweed and herbicide usage.</p> <p>https://www.extension.purdue.edu/extmedia/WS/WS-51-W.pdf A good explanation of Pigweed.</p> <p>https://www.uaex.edu/yard-garden/resource-library/weed-id/pigweed-smooth-common.aspx</p> <p>Pigweed information</p> <p>https://www.uaex.edu/farm-ranch/pest-management/weed/2017-dicamba.aspx</p> <p>Dicamba in Arkansas</p> <p>http://npic.orst.edu/factsheets/dicamba_gen.html Dicamba fact sheet</p> <p>https://pubchem.ncbi.nlm.nih.gov/compound/dicamba#section=Top This discusses Dicamba affects in the body. Very technical though</p> <p>https://www.uaex.edu/publications/pdf/FSA-2181.pdf Article on FAQ on Dicamba in Arkansas</p> <p><i>*See Appendix C for more options</i></p> <p>Reason:</p> <ol style="list-style-type: none"> 1. <i>Students construct a detailed portfolio on the position of their stakeholder.</i> 2. <i>Students evaluate and analyze other stakeholder claims during the town hall meeting.</i> <p>Class Discussion:</p> <p><i>Questions to initiate Discussion:</i></p> <p>Q: How is farming done today?</p> <p>Q: Do the students know any farmers?</p> <p>Q: What crops are grown in Arkansas and why is farming important?</p> <p>Q: How do farmers manage crops (what do they do to curtail weeds and pests)?</p> <p>Q: Why is this an essential part of farming?</p> <p>Q: How exactly do herbicides chemically affect weeds?</p> <p>Q: What are some advantages to chemical management of weeds and pests in farming?</p> <p>Q: What are some drawbacks to chemical management of weeds and pests in farming?</p> <p><i>Teacher Hints: The 'Explain' section is meant to give an overview of Dicamba and its relevance and issues to Arkansas crops. This is a good time to bring in several different concepts of your own, both chemical and biological. Feel free to add topics here that pertain to the lesson and not mentioned in the 'Explain' section.</i></p>
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what they have eaten lately (most should mention something made with grains) and then ask them where their food comes from. The most obvious answer will be the grocery store but dive deeper into the question, where does the grocery store get their food? Tie this back into the farming questions, and how do farmers grow enough for us to eat and at a price we can afford to pay? Point out that organic food is more expensive than regular food, why?

Explain:

Now teach how farmers manage input and production costs and maximize yield of their crops with herbicides and pesticides. This allows farmers to get more 'bang for their buck' so to speak. Herbicides affect

Communicate:

1. *Students use graphic media to communicate the advantages of their stakeholder position. Student will use posters, PowerPoint, etc. to present to the class.*

Class Presentations:

Q: What is the position of the stakeholder?

Q: What research backs up the stakeholder's position?

Q: What data has been acquired to defend this position to the other stakeholders?

2. *Students will defend their stakeholder position at the town hall meeting.*
3. *Students will revise their opinion of their stakeholder position in light of the class discussion.*

weeds by attacking certain areas of the plant, the most common being the growth hormone Auxin. This would be a good time to talk about the formulation of Dicamba and how it chemically works.

This lesson focuses on the herbicide Dicamba. Dicamba is a broad spectrum herbicide that mimics Auxin, causing the plant to grow so fast it dies of starvation. Dicamba is very effective in controlling pest crops, especially in ranges that cattle feed on. There is a downside to Dicamba, it is highly volatile (vaporizes easily into the air) and is quickly spread by the wind to neighboring fields. While the chemical company Monsanto (who makes Dicamba) has released crop

varieties that are resistant to Dicamba, most other crops are sensitive to this herbicide and a tiny amount can negatively impact whole fields. Soybeans in particular are highly sensitive to Dicamba, dying with just a fraction of what affects other plants. Dicamba is lethal to conifers (pines, cedar, firs, etc.) and is absorbed readily into acidic soil. Dicamba also takes longer than expected to break down in swamps and redwood forests.

So why use Dicamba? It's all about costs, yield and production efficiency. It can be used on ranges and fields to eliminate highly invasive pest weeds such as Glyphosate Resistant Pigweed, it attacks all broadleaf weeds, is cost effective and it works well.

Some farmers have expressed concern about using this herbicide as several weeds have developed resistance after only a few generations (bring up mutation-adaptation here) plus the concern of having to grow genetically modified crops to resist the Dicamba (explain what is a genetically modified plant; you could explain how a GMO plant chemically resists Dicamba). Other farmers and Monsanto representatives support the use of Dicamba, noting the drift is directly related to application error (not following treatment protocols), and state without Dicamba, highly invasive weeds like Pigweed would literally take over a field in one season.

Arkansas recently

limited the use of Dicamba to mid-October through mid-April after several farmers had crops adversely affected due to Dicamba drift. Monsanto has recently released a less volatile form of this herbicide to offset this issue.

NOTE: The 'Explain' section is meant to give an overview of Dicamba and its relevance and issues to Arkansas crops. This is a good time to bring in several different concepts of your own, both chemical and biological. Feel free to add topics here that pertain to the lesson and not mentioned in the 'Explain' section.

Elaborate:

There are nine different stake holders that will be involved in this town hall meeting. Cards explaining each

stakeholders side on the Dicamba controversy are attached to this lesson. Group students into at least groups of two (three is recommended) for each stakeholder group. Each group is to research the stakeholder's opinion they have randomly picked in order to debate this belief in the town hall meeting. Groups are expected to be prepared to defend their position and a research summary is required from each student or group (you decide). Encourage the students to make notecards in preparation for the meeting and to come with visuals to prove their point; posters, graphs and signs are great and it can even be taken further to each stakeholder group coming dressed for the part. The students will

debate their 'point of view' against the other stakeholders and in the end after the dust clears, decide if their point of view is valid or invalid based on the information gained from the other participants.

Questions that need to addressed are:

Q: What is the position of the stakeholder?

Q: What research backs up the stakeholder's position?

Q: What data has been acquired to defend this position to the other stakeholders?

A 'board' of teachers in the meeting can be used to make a final decision but ultimately the students need to be the ones who critically think through the evidence

presented and decide what they determine is the right answer.

NOTE: students may want to 'group up' at the meeting with those who's stakeholders believe like they do. You as the teacher may decide if this is a viable option.

Evaluate:

How well the students debate in the town hall meeting will determine how well prepared they were for the assignment. In the reflection letter, students will state why they either believe in their stakeholder claim or have decided against it, citing several reasons from the meeting.

Formative Assessment for Student Learning

Elicit Evidence of Learning: This box is the individual communication performance from the student prompts in Appendix A

Evidence of Student Proficiency

- **Students will have researched their stakeholder position.**
- **Students will be able to successfully debate their position at the town hall meeting.**
- **Students will have several key reasons for their decision on Dicamba usage.**

Range of Typical Student Response

Descriptors of grade-level appropriate student responses:

- *Full understanding: student is well prepared and successfully debates position. Student's Dicamba decision on reflection has at least three reasons.*
- *Partial understanding: student is partially prepared and has limited information to debate their position. Reflection had one to two reasons for Dicamba decision.*
- *Limited understanding : student is barely prepared for town hall meeting, cannot debate their position as they have little to no research and give no reasons for their Dicamba decision.*

Acting on Evidence of Learning

This is a brief description of the instructional actions to take based on the students' performance.

Description of instruction action and response to support student learning.

- *Action for student who displays partial or limited understanding: Students will be matched with an academically stronger classmate to support and guide them with research and presentation.*
- *Extensions of learning for student who displays full understanding: Students are encouraged to look at the engineering side of making sprayers more efficient with less overspray.*

SEP, CCC, DCI Featured in Lesson

Science Essentials (Student Performance Expectations From Appendix C, D, E)

Science Practices

Developing and Using Models.

Constructing Explanations and Designing Solutions.

Asking Questions and Defining Problems.

- Use a model to predict the relationships between systems or between components of a system. (CI-PS1-1)
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence and in the design; decide on types, how much and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data. (CI-PS1-6) (CI-ESS3-4)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources of stakeholder view. (CI-PS1-6) (CI-ESS3-4)
- Share explanation with others about specific stakeholder views. (CI-PS1-6) (CI-ESS3-4)
- Engage in debate from evidence presented by stakeholders.
- Work collaboratively to construct science explanations and design solutions based on evidence and problems presented at town hall meeting. (CI3-ETS1-1)
- Express a decision in writing in regards to the Dicamba issue. (CI-PS1-6) (CI-ESS3-4)

<p>Crosscutting Concepts</p> <p>Stability and Change</p> <p>Energy and Matter</p> <p>Systems and Models</p> <p>Interdependence of Science, Engineering and Technology.</p> <p>Influence of Engineering, Technology, and Science on Society and the Natural World.</p>	<ul style="list-style-type: none"> • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of and within that system. (CI-PS1-6, CI-ESS3-4) (CI-PS1-7, CI-PS1-4, CI-ESS1-2, CI-ESS2-3) • Identify things that trigger changes to a system that was previously stable. (CI-PS1-6, CI-ESS3-4) • Use units to describe orders of magnitude for volume of Dicamba spray used. (CI-PS3-1) • Models can be used to predict behavior of a system, but these predictions have limited precision and reliability due to assumptions and approximations inherent in models. (CI-PS3-1) • Explain significance of scale, proportion and quantity of Dicamba. (CI-PS3-1) • Engineers continuously modify technological systems (like sprayers) for better Dicamba usage. (CI-ESS1-2, CI-ESS2-3) • Science and engineering complement each other in the cycle know as research and development. (CI-ESS3-4)
<p>Disciplinary Core Ideas</p> <p>Chemical Reactions (PS1.B)</p> <p>Optimizing the Design Solution (ETS1.C).</p> <p>Conservation of Energy and Energy Transfer (PS3.B).</p> <p>Human Impacts on Earth Systems (ESS3.C).</p> <p>Defining and Delimiting Engineering Problems (ETS1.A).</p> <p>Developing Possible Solutions (ETS1.B).</p>	<ul style="list-style-type: none"> • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (CI-PS1-6) • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (CI-PS3-1) • Scientists and engineers can make major contributions by developing technologies (better sprayers, less volatile Dicamba) that produce less pollution and waste and that preclude ecosystem degradation. (CI-ESS3-4) • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account (Dicamba Drift) and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (CI-ETS1-1) • Humanity faces major global challenges today such as food, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (CI-ETS1-1) • When evaluating solutions to the Dicamba debate, it is important to take into account a range of constraints including cost, safety,

reliability and aesthetics, and consider social, cultural and environmental impacts. Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria other others may be needed. (CI-ESS3-4)

Appendices: This section contains the lesson performance that students will see during the lesson and any other resources students will use to engage in the science performances. The appendices may also contain examples of student work.

Appendix A - Student Prompts

Student Prompts for the Lesson

Phenomenon:

Due to increasing demand for higher food production, herbicides like Dicamba are used on commercial crops to kill highly invasive weeds. Unfortunately, Dicamba also causes increased resistant strains and can damage nearby sensitive crops. It also favors growing GMO crops that are resistant to Dicamba.

Group Performances:

1. Ask questions to plan an investigation for the research of Dicamba in the stakeholder view for the town hall meeting.
2. Plan an investigation to gather evidence for Dicamba usage, causing or not causing, changes in the system.
3. Construct an explanation for the cause or no cause of changes in the system by Dicamba usage.
4. Use a model to defend a stakeholder position in regards to Dicamba usage.

Class Discussion

Individual Performances:

5. Develop an argument for how the evidence you collected supports or refutes your explanation for your support for or against the use of Dicamba.
6. Decide if your argument is valid in light of classroom discussion

Appendix B – Materials, Prep Time and Extend Section

Materials:

- Stakeholder cards (at end of lesson)
- Notebooks for notes
- Research material for stakeholder information
- Various media/graphic material for town hall meeting

Teacher Preparation Time:

Make up cards before the lesson. The lesson time varies depending on the amount of time you want to give to the students to research their position. This lesson should be a minimum of one week to give students at least a few days for research. The town hall meeting will take a full class period.

Extend:

This lesson can be tied into several different new concepts such as biodiversity, population dynamics, adaptation, phase changes and Bernoulli's Principle. It is a good lead into engineering and how to make sprayers more efficient and less messy when releasing spray. Mathematics can be brought in to determine spray volume per acre, temperature levels for volatility and atmospheric pressure concerns when spraying.

Appendix C – resources:

There are a number of websites that are worth checking out for this lesson. Here are some examples:

<http://scholarworks.uark.edu/cgi/viewcontent.cgi?article=1608&context=etd> Covers Pigweed and herbicide usage.

<https://www.extension.purdue.edu/extmedia/WS/WS-51-W.pdf> A good explanation of Pigweed.

<https://www.uaex.edu/yard-garden/resource-library/weed-id/pigweed-smooth-common.aspx>

Pigweed information

<https://www.uaex.edu/farm-ranch/pest-management/weed/2017-dicamba.aspx> Dicamba in Arkansas

http://npic.orst.edu/factsheets/dicamba_gen.html Dicamba fact sheet

<https://pubchem.ncbi.nlm.nih.gov/compound/dicamba#section=Top> This discusses Dicamba affects in the body. Very technical though

<https://www.uaex.edu/publications/pdf/FSA-2181.pdf> Article on FAQ on Dicamba in Arkansas

<https://www.bing.com/images/search?q=photos+of+dicamba+damaged+crops&qvvt=photos+of+dicamba+damaged+crops&FORM=IGRE> Photos of Dicamba damaged crops

<https://cen.acs.org/articles/95/i33/Widespread-crop-damage-dicamba-herbicide.html>
Dicamba damage

<https://www.agclaimsassociation.com/single-post/2017/09/19/Dicamba-Lawsuits-Mounting>
Dicamba lawsuits

<https://www.usnews.com/news/best-states/arkansas/articles/2018-02-16/judge-considers-companys-challenge-to-arkansas-dicamba-ban> Arkansas lawsuits

STAKEHOLDER SHEETS

Sensitive Sam, Farmer: While you are not against herbicides and pesticides in general (and use pesticides on your soybeans to control the Red Banded Stinkbug), you do have an issue with Dicamba. Your soybeans are very sensitive to Dicamba and with your life savings growing out in the field, one drift would wipe you out financially. Certainly there are other alternatives that don't threaten your pocketbook! So not only will you be bringing reasons why you are against Dicamba, you also plan on bringing up those alternatives at the meeting.

Tolerant Tom, Farmer: You grow Dicamba resistant soybeans and Dicamba has literally saved your bacon in the Pigweed department! Glyphosate resistant Pigweed literally had you hog tied financially as it took over your soybean fields. Dicamba took out the plant and gave you back a crop producing farm, causing you to squeal with happiness! Not only are you for Dicamba but now that there is a less volatile version available, you believe that it should be reinstated for use all year round and will expound on this at the meeting. You understand other's concerns. Your concern is that outside folks who don't farm listen more to the internet than to folks like yourself who have worked and protected the land for generations. Your land is your future and hopefully will provide a future for your children. The banker who holds your farming loan for this year's crop expects his repayment on time. Don't these folks understand that if yield is decreased, more folks around the world who depend on soy protein will die? You have nothing against organic producers as they give the consumer choices but organic practices simply won't feed the world's growing population. You do the math.

Al Naturale, Organic Farmer: You are all about the ‘no artificial chemicals’ part of farming. It’s natural fertilizer and homeopathic pesticides for you! Not only do you feel organic food is better for the body, it’s also better for the environment! Dicamba has been used so much it is now showing up in the soil and waterways. Plants absorb Dicamba that is present in the soil meaning people are eating Dicamba for dinner. You are against using an artificial chemical that not only has the potential to harm the environment (killing beneficial broadleaf plants due to spray drift, plus new resistant invasive species created due to Dicamba use) but also we really don’t know the overall human health impact Dicamba can have long term. You are going to hit Monsanto and Dicamba users with health and holistic facts why Dicamba is bad. The fact that organic farming is much more expensive (meaning higher prices at the grocery store) and not using Dicamba would bring normal crop prices more in line with organic (thus making organic more competitive) is also a strong point but you are hoping it won’t be brought up at the meeting!

Beau Vine; Cattle Rancher: You own a large cattle ranch and love Dicamba. Dicamba has done wonders in keeping noxious invasive weeds out of your grazing areas and your cattle have never been fatter! You consider Dicamba a godsend for grazing animals and welcome its use. You will be at the meeting with facts in hand as to the benefits of Dicamba to local ranchers.

Samore Sales, Monsanto Company Representative: As the representative for the company, you obviously feel Dicamba has been given a bum rap. Without Dicamba, Pigweed and other highly invasive pest weeds would have taken over Arkansas and we would be singing the ‘Woo Pigweed Soobie’ song at Razorback games! The issues with Dicamba are due to application error and not applying at the right times. Besides, Monsanto has come out with a less volatile chemical so the whole drift problem is solved right? You plan to bring all the advantages of Dicamba to the meeting and more!

Kris Kringle, Christmas Tree Farmer: You produce Conifers (mainly firs and pines) on a local tree farm for Christmas and your farm is located next to a large soybean field. You have had dealings with Dicamba drift in the past, with many of your trees dying from the spray. You are not seeing the big ‘change’ that Monsanto is crowing about in regards to a lower drift potential as your soybean neighbors have told you they are now using the improved spray but you are still dealing with dead trees. You are planning on grilling Monsanto at the meeting about this new formulated spray and what they are going to do about your dead tree problem.

Connie Consumer: You are the local advocate for responsible farming. You and your cohorts worry about what exactly are we eating at the dinner table. While there is the understanding that herbicides are necessary for weed control, what do we really know about Dicamba and its effect on the human body? Plus, there is all this talk about Dicamba Drift so could organic food have Dicamba spray on it? As a participant in this meeting you come prepared to ask lots of questions about the risks of Dicamba in our food and our bodies and to argue your concerns.

Debbie Dicot, Plant Pathologist: As the local expert on invasive weeds and how Dicamba works, you have the distinction of being the only stakeholder who is trying hard not to take sides. You see the benefits of Dicamba as Glyphosate Resistant Pigweed (*Amaranthus palmeri*) is an extremely invasive species that outcompetes every crop known. It's fast growing, has high genetic variability (that leads to resistant plants) and produces on average over 500,000 small seeds per plant. Dicamba is one of the few herbicides on the market that can control this Pigweed in soybeans so you know the benefits of this chemical. You are also aware of the damage this herbicide can do to neighboring fields due to drift and the economic impact this has on the affected farmers. You come to the meeting ready to defend both opinions but to also offer alternatives that will help lower Dicamba usage and hopefully benefit both sides.

Lau Suit, Attorney: You represent those people who have been affected by Dicamba Drift. Your specialty is Agriculture Law and it is you against the big corporate lawyers on this one. Not only do you represent farmers but you also represent homeowners and other innocent victims of this herbicide. You plan to come to this meeting armed with facts about the legal ramifications of this spray's issues and plan on citing the latest legal activity here in Arkansas that focuses on Dicamba.