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Binary #MicDropMath Patterns

Find all related files to print and videos for this lesson here:
https://stemazing.org/binary-mic-drop-math-patterns/

Recommended Order of Binary #MicDropMath Lessons:

While all these lessons can stand on their own, in a perfect world with eons of time to engage students, the following would be the recommended sequence:

- Binary #MicDropMath Patterns
- Binary #MicDropMath Build Your Own Cards
- Binary #MicDropMath Multiply This
- Human Computers – Creative Message Communication

These can all be found here: https://stemazing.org/binary-mic-drop-math-lessons/

This lesson can be used to help students recognize patterns, understand how to make multiple hypotheses in science and math, and understand the importance of basing claims on more data rather than less. It also serves as an introduction to the binary number system.

Materials:

Binary #MicDropMath Cards (0-31 version, page one only)
Binary #MicDropMath Cards (0-63 version, page one only)
(available here: https://stemazing.org/binary-mic-drop-math-cards/)
Graph paper for taking notes (you might consider having them make STEMAZing Journals like these: https://stemazing.org/stemazing-journal-hack/)
Pens/Pencils

You will need one set of the 0-31 cards per student. Sort them into stacks of cards that are the same – all the cards with 1 in the top left corner together, all the cards with 2 in the top left corner together, and so on.

You will need one set of the 0-63 cards per student. Keep these in complete sets of six cards. It is best to print the 0-31 and 0-63 cards on two different colors of paper so they can be easily sorted.

NOTE: The terms “magic” and “trick” are purposely being avoided. This is not magic, it is beautiful mathematics. Using a term like “math magic” implies a mysticism or mystery related to math, which we want to avoid. Historically, math tricks represent numerous shortcuts which undermine student number sense and conceptual understanding. Everyone can learn and understand math. There is no magic to it! We are adopting the term “Mic Drop Math” in place of magic and trick, and we hope you will do the same.

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Engage:

Write the number 10011011 on the board and 177. As your students which number is bigger and have them write their answer in their journals. Then, explain to them that 177 is actually the larger value. 10011011 has a value of 155 in base 2 and 177 has a value of 177 in base 10, the number system we are used to using. Ask your students to write down in their journals the value the number represents. Explain that they will understand why by the end of this lesson.

Explore:

Explain to students: “Noticing and describing patterns in math and science is a critical skill. Today we are going to be looking for patterns on the cards I am giving you. I want you to write any patterns you notice in your journal and then I will give you some time to share what you notice with others at your table.” There is a PowerPoint of these cards being revealed in order, which you can find here: https://stemazing.org/binary-mic-drop-math-patterns/

1	3	5	7
9	11	13	15
17	19	21	23
25	27	29	31

Hand every student JUST the first card from the set. (Pictured at right.) First, give them about 3-5 minutes to write silently in their journal. You may prompt them with questions like: What patterns do you notice? What numbers are on the card? What numbers are not on the card? After they have made their own individual observations, let them share out what they noticed in small groups of 3-5 students. Once students have discussed the patterns in their small groups, facilitate a share-out by allowing each group to share something they noticed until you have exhausted patterns and observations made by the class.

2	3	6	7
10	11	14	15
18	19	22	23
26	27	30	31

Now, hand every student the SECOND card from the set, pictured at right. Let them keep the first one as well. Again, repeat the 3-5 minutes of silent observation of patterns, which they should write in their journals, followed by sharing with their small group. You may prompt them with questions like: What patterns do you notice on the second card? What number are on the card? What numbers are not on the card? What numbers does it have in common with the first card? Once students have discussed the patterns in their small groups, facilitate a share-out by allowing each group to share something they noticed until you have exhausted patterns and observations made by the class.

Now have students make a prediction. What do they think the numbers on the third card are going to be? Let them discuss with their small groups and then share out their ideas with the class. Do not hand out the third card until they have made a prediction. It is

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most likely true that they will predict it will start with a 3 unless they have seen this #MicDropMath before.

4	5	6	7
12	13	14	15
20	21	22	23
28	29	30	31

Next, hand every student the THIRD card from the set, pictured at right. Allow them to discuss patterns in their small groups but be sure they also record what they notice in their journals. Many will be surprised the card did not have a 3 in the top left square. After they have discussed patterns on this card, let them again share out with the entire class. Before handing them the next card, have them make as many hypotheses about what the number on the top left of the next card will be. In science and math, we don't want just one option for a hypothesis. We want to try to find patterns which support as many different options as we can possibly think of to help us avoid our bias. In this case, they should be able to find three or four patterns to support different predictions from 6 (after the first card an increase of two each time), 7 (+1, +2, so the next card would be +3), 8 (doubling each time), 16 (besides first one, squaring each time). They may come up with a few others, which should all be celebrated.

8	9	10	11
12	13	14	15
24	25	26	27
28	29	30	31

Hand every student the FOURTH card from the set, pictured at right. Did they have a hypothesis that predicted what they would find? Have them note any patterns they see on this card. Explain that there is only one card left in the set. Ask them to, again, predict what numbers the last card will have on it and record their prediction in their journal. Can they come up with more than one hypothesis based on patterns in the cards?

It is unlikely they will be able to support any other prediction other than the next card starting with 16. At this point, we have quite a bit of evidence, four data points to support this pattern.

16	17	18	19
20	21	22	23
24	25	26	27
28	29	30	31

Finally, hand out the last card in the set, pictured at right. Give them some time to discuss whether their prediction matched the actual card. Now that they have all five cards, ask them if they can find any numbers which appear on just one and only one card. What do they notice about these numbers? (It is possible someone may have noticed this before this point as well.) They should be able to figure out that 1, 2, 4, 8, and 16 only appear on one card. Ask them what the next card in this series would start with? 32 And the next? 64 And the next? 128 and so on.

It is time to wow them with the binary #MicDropMath. Take a complete set of cards or use the PowerPoint Version 1-31 presentation found here https://stemazing.org/binary-mic-drop-math-patterns/. Pick one student to think about, but not share aloud, the number for the day they were born. Tell them to ignore the month and year and just

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think about the number for the day they were born. Now, ask them to simply view each card and answer "yes" or "no" indicating if they see their number on the card or not. Keep a running total of the top left hand numbers on the cards to which they say "yes". This value is the number for the day they were born. See examples below. You should do the trick on two or three students to prove it was not a fluke.

If they were to say "yes" to the following cards and "no" to the other two:

8	9	10	11
12	13	14	15
24	25	26	27
28	29	30	31

4	5	6	7
12	13	14	15
20	21	22	23
28	29	30	31

1	3	5	7
9	11	13	15
17	19	21	23
25	27	29	31

Then, they were born on the 13th of the month: 8 + 4 + 1 = 13
This is the sum of the numbers in the top left corner of the cards to which they said yes, indicating their number was on that card.

Another example, if they said "yes" their number is on the following cards and "no" to the others:

16	17	18	19
20	21	22	23
24	25	26	27
28	29	30	31

4	5	6	7
12	13	14	15
20	21	22	23
28	29	30	31

Then, they were born on the 20th of the month: 16 + 4 = 20

Should they say "yes" to only one card, then their birth day is simply the number in the top left corner of that card. You can also use the cards to figure out their birth month and if your students were born after 2000, you can figure out their two digit birth year as well.

At this point, you can decide if you are going to immediately share the #MicDropMath with them or make them figure it out themselves. You could ask them to think about why you would want to know if their number is on the card. It must be that the cards to which you say "yes" allow you to, somehow, figure out the number. You could select a few more students and have the class move the yes cards together. Tell them what the number is and see if they can figure out how you get it. As students figure it out, ask them not to share the secret with the class but rather, let you think of a number and test if they really do get it by answering "yes" or "no" to their cards. This could either be done as whole class or small groups.

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After a sufficient amount of productive struggle, you should let the entire class in on the secret and let them practice on each other – one student thinking of a number between 1-31 and the other attempting to figure it out.

Explain:

Tell students this #MicDropMath is based on the binary number system. To explain the binary system, show this video until 3:45 when it becomes an advertisement for the sponsor: https://bit.ly/BinaryNumbersFast

The video will cover positional notation, binary numbers, base ten, numeral base systems, alphanumberic characters, and URL shorteners. List these vocabulary words on the board and have students watch the video once all the way through listening for these terms in particular. Then, watch the video again pausing after each word is referenced, and try to come up with a definition for each term. This could be discussed and decided upon in their small groups and then shared out with the class.

Binary Numbers – a numeral base system which uses only two numbers – 1 and 0

Base Ten – a numerals system which uses ten symbols, the digits 0-9

Numeral Base Systems – systems which uses only the digits 0-9 or a subset of those digits to represent different values – examples are base 10 (which we use every day), base 2 or binary which uses just two values, but there are also base three, base four, and so on.

Positional Notation – addition of new locations to the left of the initial position once when its maximum value has been reached. Each new position has a value which is a factor of the number of symbols you are using greater than the position to its right.

Alphanumeric Characters – systems which use both numbers and letters

URL Shorteners – take long website URLs and shorten them using alphanumeric strings to give them a unique, but short, URL

Elaborate:

Now, give each student a complete set of the Advanced Version of the Binary #MicDropMath (0-63 version). They should be given time to discuss how these cards are similar and different from the first set of cards they received. You can ask them: Do the patterns they noted in the first set of cards still hold?

One pattern, which is often missed, would allow students to quickly make their own cards up to any number they want. If you are going to do the Binary #MicDrop Math – Make Your Own Cards lesson, you may not want to share this with them now. It is up to you. This pattern requires that you remember to include the number zero, which is sadly often left out.

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Write down the following numbers on the board and ask students to write them in their journals:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

For the first card, ask students to cross out numbers which do not appear on the first card in the first row. Cross out the numbers which do not appear on the second card in the second row. Third card, third row and fourth card, fourth row – same directions.

This is what they should see:

1	~~0~~	1	~~2~~	3	~~4~~	5	~~6~~	7	~~8~~	9	~~10~~	11	~~12~~	13	~~14~~	15	~~16~~
2	~~0~~	~~1~~	2	3	~~4~~	~~5~~	6	7	~~8~~	~~9~~	10	11	~~12~~	~~13~~	14	15	~~16~~
4	~~0~~	~~1~~	~~2~~	~~3~~	4	5	6	7	~~8~~	~~9~~	~~10~~	~~11~~	12	13	14	15	~~16~~
8	~~0~~	~~1~~	~~2~~	~~3~~	~~4~~	~~5~~	~~6~~	~~7~~	8	9	10	11	12	13	14	15	~~16~~

Ask students if they can describe in one or two sentences, the pattern established above? How could you generalize the rule to each new card you might want to add to your set? Does this pattern hold true for the six-card 0-63 version of this #MicDropMath? (Because it is recommended you wait to let students explore this pattern until you are doing the Binary #MicDropMath Build Your Own Cards lesson, you will find it in the PowerPoint for that lesson here: https://stemazing.org/binary-mic-drop-math-build-your-own-cards/)

Have students practice the Binary #MicDropMath on each other with one student thinking of a number between 1-63 and the other student figuring it out. This works the same way as the first set of cards – just simply add up the top left corner numbers on the cards they say “yes” to and the sum is the number they picked.

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Any of the lessons from CSunplugged in the Binary numbers unit would be a great extension to this lesson. Find those lessons with printables, directions, and videos for each lesson here: https://csunplugged.org/en/topics/binary-numbers/

Do not be fooled by the low age range of the CSunplugged lessons. Most adults do not know this stuff. This unit includes lesson on the following:
Binary Candles or Normal Candles on your Cake
Binary Name Necklaces
Binary Tunes

Evaluation:

Students can be challenged to take the Binary #MicDropMath home with them to show off their number devising skills with their families. Remind them to avoid calling it magic or a trick but rather use the term #MicDropMath.

You could give them binary numbers to evaluate and see if they can actually come up with the correct value.

As students still do not generally understand where the numbers on the specific cards actually come from, it is recommended that you us the Binary #MicDropMath Build Your Own Trick Cards lesson to let them discover how you determine which numbers go on each card used for this trick. This lesson allows students to replicate the 0-31 cards or they can challenge themselves with developing the 0-63 or even 0-127 cards.

Once they have built their own cards, they will have a much better sense of how the binary number system actually works. It is important that students know that the binary number base 2 system is just another way of representing numbers. While it seems hard to us because we have not been engaged to use it frequently, if we used it every day and we were just now being introduced to the decimal base 10 number system, it would seem really weird to us. It is also important to note that binary numbers have been around for a very long time. They are, in fact, the foundation for some old multiplication algorithms used in Russia and even ancient Egypt. Students can learn more about all of that in the Binary #MicDropMath Explains Russian and Egyptian Multiplication Algorithms lesson. This lesson also teaches students how to add and multiply binary numbers.

Students can also take all they have learned and go a step further to learn about data error detection and correction using parity bits. This lesson, called Human Computers – Creative Message Communication also shows students how to use cards cut from a cereal box to code secret messages to their friends.

All lessons mentioned above can be found here:
https://stemazing.org/binary-mic-drop-math-lessons/