



GEMS Challenges ---- Error Detection

SUBJECT

Computer Science

Suggested grades

4-12

Cautions/concerns

Be prepared to do this activity again and again.

The Challenge—Understand how computers check for errors in data transmission**LEADER ACTIONS****GIRL ACTIONS**

INTRODUCTION	Read the challenge—when computers are transmitting data at a million or more bits per second, how do you know that their data has no errors?	Brainstorm options—this will be a new concept for them
BACKGROUND INFORMATION	<p>Present the concept of error detection—quickly knowing that data has been transmitted correctly. Remind girls that data is transmitted 64 bits (tiny pieces of data) at a time.</p> <p>“There are a lot of ways to count, but when it comes to computers there is only binary: 0 and 1. Each one is a considered a “bit.” That means for 1-bit computing, you get two possible values; 2-bit means four values; then at 3 bits you double that to eight (2 to the third power, aka 2 cubed). Keep going exponentially and you eventually get 32-bit (2 to the 32nd power) worth 4,294,967,296; 64-bit (or 2 to the 64th power) is worth 18,446,744,073,709,551,616 values.”--PCMAG</p>	
ACTIVITY	<p>Do the demonstration, as shown in the lesson from CSUnplugged. Have a student tape or magnet the large cards in a 5 x 5 grid mixing up the two colors as shown in the picture. Add the “one more row” to the top and side, making a six by six grid, being sure that there is an even number of cards in each row and column. Make sure this is correct before you start.</p> <p>Ask a girl to come up and turn over one</p>	<p>One girl comes up and turns over one card to the other side.</p> <p>All girls watch while</p>

LEADER ACTIONS

GIRL ACTIONS

	<p>card while you hide your eyes. Make sure she knows to make all the cards even so you can't tell.</p> <p>After pretending to scan all the cards, point to the one which was turned. (It is the row and column which no longer have even numbers). Ask the girls how they think you knew. Do it again several times. Make sure that things are reset before you try again.</p> <p>When you feel that they have guessed enough, show them how it works. Show them that you always start with an even number in each row and column, and that you scan them for the oddity. Let a couple of girls try it.</p> <p>Pass out their individual sets and let them try it.</p>	<p>leader figures out which one was turned.</p> <p>Figure out how she did this.</p> <p>Try the activity with a team mate.</p>
CONCLUSION	<p>Review the activity with the girls. They may see this as just an activity but point out the examples in the lesson, and how data is used every day. Credit cards, text message, emails—you want everything you send or get to be correct.</p> <p>This is a new concept and it may not make a lot of sense but here is a good concluding piece of information.</p> <p>"The same technique as was used in the "card flip" game is used on computers. By putting the bits into imaginary rows and columns, and adding parity bits to each row and column, we can not only detect if an error has occurred, but <i>where</i> it has occurred. The offending bit is changed back, and so we have performed error correction."</p>	<p>Think about errors in data and the importance of correct transmission.</p>
REFLECTION	<p>Have two-three girls choose one of the reflection cards and reflect on her experience.</p>	<p>Reflect on this activity</p>

Supplies

Teacher demo cards—
large squares of two-
colored cardstock.
Masking tape or magnets

Preparation needed

- **READ** the whole lesson from CSUnplugged. There is a lot of great background information

Comments

Welcome to a whole possibly new area of learning-- computational thinking. This may be challenging for you and the girls but it can be very

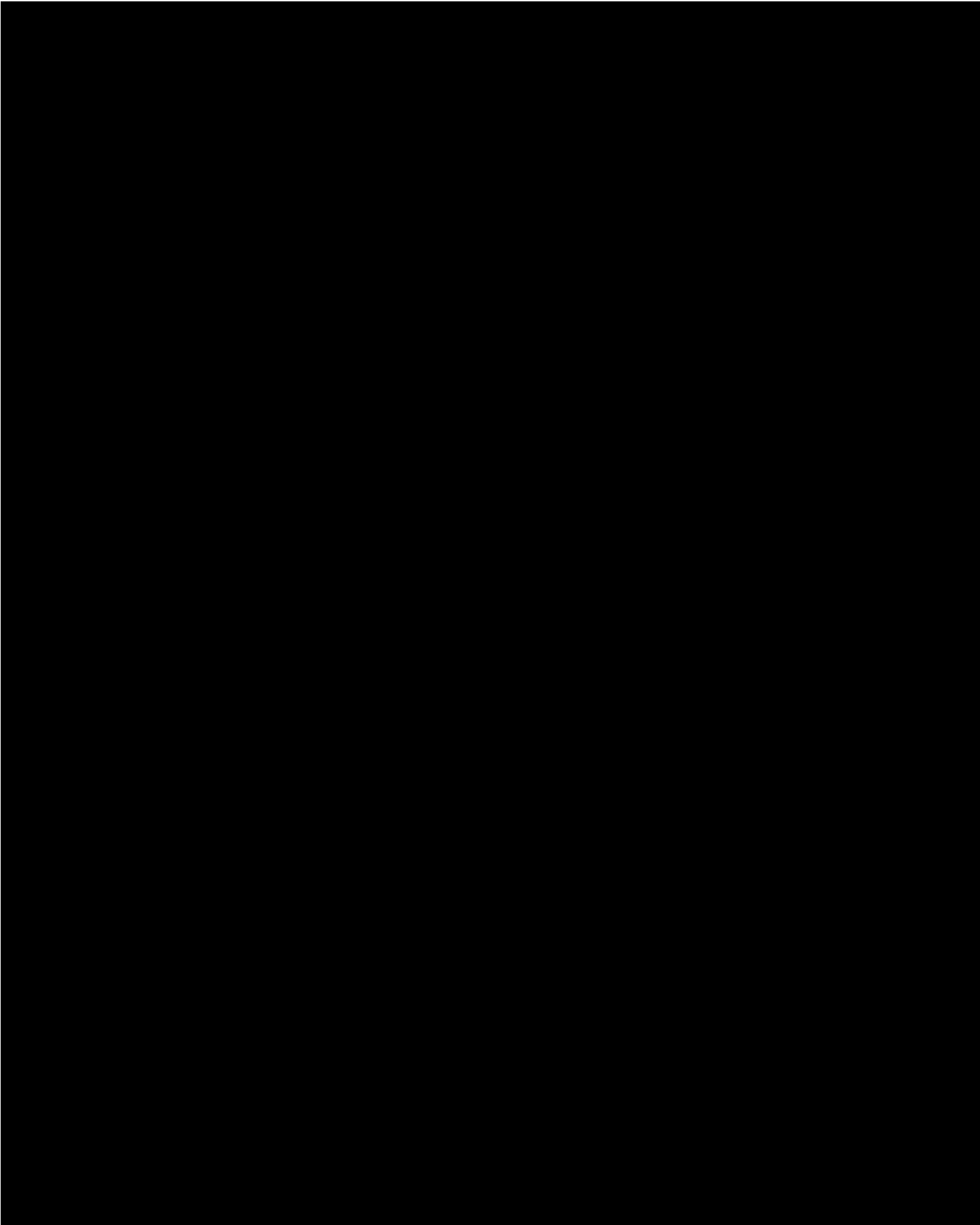
Student sets of two-sided cardstock—3 x 3 cards—40 cards per team of 2

so that you can answer questions.

- Prepare the cards—you can use magnets or tape for the demo.

interesting and is a part of our daily life.

This is based on the Card Flip Magic Lesson from CSUnplugged



Activity 4

Card Flip Magic—*Error Detection & Correction*

Summary

When data is stored on a disk or transmitted from one computer to another, we usually assume that it doesn't get changed in the process. But sometimes things go wrong and the data is changed accidentally. This activity uses a magic trick to show how to detect when data has been corrupted, and to correct it.

Curriculum Links

- ✓ Mathematics: Number Level 3 and up. Exploring computation and estimation.
- ✓ Algebra Level 3 and up. Exploring patterns and relationships.

Skills

- ✓ Counting
- ✓ Recognition of odd and even numbers

Ages

- ✓ 9 years and up

Materials

- ✓ A set of 36 “fridge magnet” cards, coloured on one side only
- ✓ A metal board (a whiteboard works well) for the demonstration.

Each pair of children will need:

- ✓ 36 identical cards, coloured on one side only.

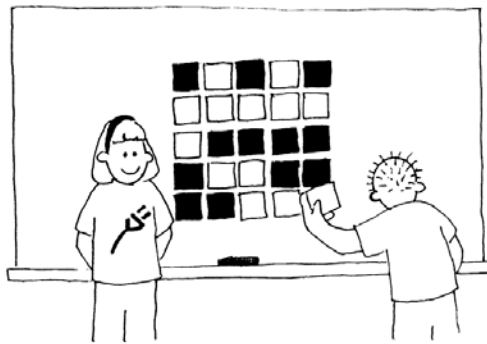
The “Magic Trick”

Demonstration

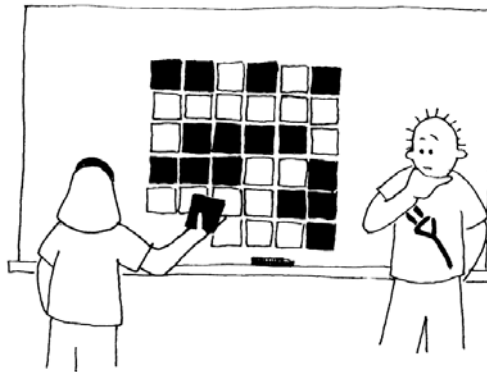
Here’s your chance to be a magician!

You will need a pile of identical, two-sided cards. (To make your own cut up a large sheet of card that is coloured on one side only). For the demonstration it is easiest to use flat magnetic cards that have a different colour on each side—fridge magnets are ideal.

1. Choose a child to lay out the cards in a 5×5 square, with a random mixture of sides showing.



Casually add another row and column, “just to make it a bit harder”.



These cards are the key to the trick. You must choose the extra cards to ensure that there is an even number of coloured cards in each row and column.

2. Get a child to flip over one card only while you cover your eyes. The row and column containing the changed card will now have an odd number of coloured cards, and this will identify the changed card.

Can the children guess how the trick is done?

Teach the trick to the children:

1. Working in pairs, the children lay out their cards 5×5 .
2. How many coloured cards are there in each row and column? Is it an odd or even number? Remember, 0 is an even number.
 3. Now add a sixth card to each row, making sure the number of coloured cards is always even. This extra card is called a “parity” card.
 4. Add a sixth row of cards along the bottom, to make the number of cards in each column an even number.
 5. Now flip a card. What do you notice about the row and column? (They will have an odd number of coloured cards.) Parity cards are used to show you when a mistake has been made.
 6. Now take turns to perform the ‘trick’.

Extension Activities:

1. Try using other objects. Anything that has two ‘states’ is suitable. For example, you could use playing cards, coins (heads or tails) or cards with 0 or 1 printed on them (to relate to the binary system).
2. What happens if two, or more, cards are flipped? (It is not always possible to know exactly which two cards were flipped, although it is possible to tell that something has been changed. You can usually narrow it down to one of two pairs of cards. With 4 flips it is possible that all the parity bits will be correct afterwards, and so the error could go undetected.)
3. Another interesting exercise is to consider the lower right-hand card. If you choose it to be the correct one for the column above, then will it be correct for the row to its left? (The answer is yes, always.)
4. In this card exercise we have used even parity—using an even number of coloured cards. Can we do it with odd parity? (This is possible, but the lower right-hand card only works out the same for its row and column if the numbers of rows and columns are both even or both odd. For example, a 5×9 layout will work fine, or a 4×6 , but a 3×4 layout won’t.)

A Real-Life Example for Experts!

This same checking technique is used with book codes. Published books have a ten-digit code usually found on the back cover. The tenth digit is a check digit, just like the parity bits in the exercise.

This means that if you order a book using its ISBN (International Standard Book Number), the publisher can check that you haven't made a mistake. They simply look at the checksum. That way you don't end up waiting for the wrong book!

Here's how to work out the checksum:

Multiply the first digit by ten, the second by nine, the third by eight, and so on, down to the ninth digit multiplied by two. Each of these values is then added together.

For example, the ISBN 0-13-911991-4 gives a value

$$\begin{aligned} & (0 \times 10) + (1 \times 9) + (3 \times 8) + (9 \times 7) + (1 \times 6) \\ & + (1 \times 5) + (9 \times 4) + (9 \times 3) + (1 \times 2) \\ & = 172 \end{aligned}$$

Then divide your answer by eleven. What is the remainder?

$$172 \div 11 = 15 \text{ remainder } 7$$

If the remainder is zero, then the checksum is zero, otherwise subtract the remainder from 11 to get the checksum.

$$11 - 7 = 4$$

Look back. Is this the last digit of the ISBN? Yes!

If the last digit of the ISBN wasn't a four, then we would know that a mistake had been made.

It is possible to come up with a checksum of the value of 10, which would require more than one digit. When this happens, the character X is used.

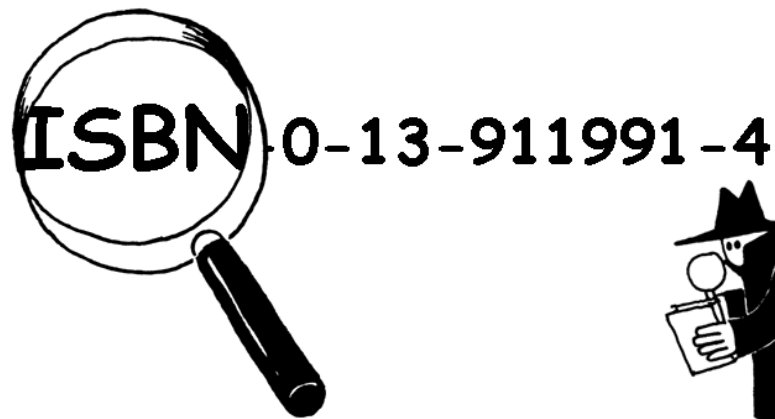


▲ A barcode (UPC) from a box of Weet-Bix™

Another example of the use of a check digit is the bar codes on grocery items. This uses a different formula. If a bar code is misread the final digit should be different from its calculated value. When this happens the scanner beeps and the checkout operator re-scans the code.

Check that book!

Detective Blockbuster
Book Tracking Service, Inc.



We find and check ISBN checksums for a small fee.

Join our agency—look in your classroom or library for real ISBN codes.

Are their checksums correct?

Sometimes errors are made.

Some of the common errors are:

- ✗ a digit has its value changed;
- ✗ two adjacent digits are swapped with each other;
- ✗ a digit is inserted in the number; and
- ✗ a digit is removed from the number

Can you find a book with the letter X for a checksum of 10? It shouldn't be too hard to find—one in every 11 should have it.

What sort of errors might occur that wouldn't be detected? Can you change a digit and still get the correct checksum? What if two digits are swapped (a common typing error)?

What's it all about?

Imagine you are depositing \$10 cash into your bank account. The teller types in the amount of the deposit, and it is sent to a central computer. But suppose some interference occurs on the line while the amount is being sent, and the code for \$10 is changed to \$1,000. No problem if you are the customer, but clearly a problem for the bank!

It is important to detect errors in transmitted data. So a receiving computer needs to check that the data coming to it has not been corrupted by some sort of electrical interference on the line. Sometimes the original data can be sent again when an error has been transmitted, but there are some situations when this is not feasible, for example if a disk or tape has been corrupted by exposure to magnetic or electrical radiation, by heat or by physical damage. If data is received from a deep space probe, it would be very tedious to wait for retransmission if an error had occurred! (It takes just over half an hour to get a radio signal from Jupiter when it is at its closest to Earth!)

We need to be able to recognize when the data has been corrupted (*error detection*) and to be able to reconstruct the original data (*error correction*).

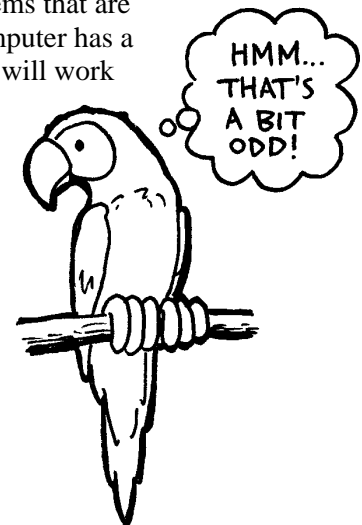
The same technique as was used in the “card flip” game is used on computers. By putting the bits into imaginary rows and columns, and adding parity bits to each row and column, we can not only detect if an error has occurred, but *where* it has occurred. The offending bit is changed back, and so we have performed error correction.

Of course computers often use more complex error control systems that are able to detect and correct multiple errors. The hard disk in a computer has a large amount of its space allocated to correcting errors so that it will work reliably even if parts of the disk fail. The systems used for this are closely related to the parity scheme.

And to finish, a joke that is better appreciated after doing this activity:

Q: What do you call this: “Pieces of nine, pieces of nine”?

A: A parrotty error.



Solutions and hints

Errors that would not be detected are those where one digit increases and another decreases. Then the sum might still be the same.