EZIE MAKERPLACE FIELD GUIDE

Making the Invisible Observable: From Evidence to Meaning

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For learners who are seekers - budding scientists investigating magnetic fields and the dynamic Sun-Earth system

THE BIG IDEA

Earth has a strong magnetic field that is always present, but it is not perfectly static. A ground magnetometer measures the magnetic field at its own location. Most of the time, learners see a background field with smaller changes layered on top of it. Some changes may be connected to processes in the space environment around Earth; others may come from something very local, such as moving the sensor, a nearby magnet, a vehicle, or electrical equipment.

The instructional goal is not to jump from a graph to a cause. It is to help learners observe carefully, look for changes through time, compare evidence across places and instruments, test whether a pattern repeats, and build explanations that say only what the evidence currently supports.

WHY KEEP MEASURING?

One measurement gives us a number from one place at one moment. Continuous measurements give us a story of change. Over minutes, hours, days, months, and years, learners can begin to recognize what is typical, notice when something changes, determine how quickly a change happens and how long it lasts, and ask whether other locations observed something similar.

A useful student idea: One measurement tells us what the magnetic field was like at one moment. Repeated measurements help us discover patterns and decide whether an observation is repeatable rather than a one-time event or instrument problem.

THE EVIDENCE-TO-MEANING LEARNING PROGRESSION

SEE	**NOTICE**	**COMPARE**	**CONNECT**	**QUESTION**	**REPEAT / TEST**	**EXPLAIN**
What does our local magnetometer show?	What patterns or changes stand out?	What is similar or different across time or place?	What other evidence relates to what we see?	What new questions emerge?	Does the pattern happen again or appear in other evidence?	What does the evidence support - and not yet support?

A SIMPLE PHYSICAL STORY

The Sun continuously releases energy and particles into space. Changes in that solar environment can disturb near-Earth space. Those disturbances can produce electrical currents in near-Earth space and the upper atmosphere, and those currents produce magnetic fields of their own. A ground magnetometer can detect some of the resulting changes in the magnetic field at its location.

Important scientific distinction: the magnetometer is not directly measuring the solar wind or the aurora. It measures the magnetic field here. We use timing, patterns, other magnetometers, auroral observations, space-weather information, and EZIE observations to investigate what may have produced the changes.

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Investigating Earth's Magnetic Field as a System

FIVE SYSTEMS-THINKING CHARACTERISTICS

Use these characteristics as question generators, not simply as vocabulary to memorize.

1. INPUTS / OUTPUTS What enters, influences, changes, or emerges from the system?

- What is happening beyond Earth that might influence what we measure locally?
- What changes do we observe in our magnetometer data?
- Where might energy or information be entering, moving through, or emerging from the system?

2. INTERACTIONS What other systems interact with this system?

- How does Earth's magnetic environment interact with solar and near-Earth space processes?
- What relationships might we investigate among magnetometer patterns, auroral observations, space-weather information, and EZIE observations?
- Which relationships are supported by timing and repeated evidence, and which are only possibilities?

3. COMPONENTS What smaller systems, instruments, places, and processes help us understand the larger system?

- What can our local magnetometer tell us - and what can it not tell us alone?
- What can another MakerPlace magnetometer add?
- How do ground magnetometers, auroral observations, space-weather measurements, and EZIE each observe different pieces of the connected system?

4. PROPERTIES What characteristics can we observe or measure?

- Look for pattern, direction, magnitude, timing, duration, variability, repetition, similarity, difference, and location.
- What changed? How much? How quickly? How long did it last? Did it repeat? Was it unusual compared with the background?

5. BOUNDARIES Where does the system begin and end - and does the boundary depend on our question?

- Are we studying our instrument site, our community, a region, Earth's magnetic environment, near-Earth space, or the larger Sun-Earth system?
- What happens to our explanation when we zoom inward or outward? Could a change be local to the instrument rather than part of the larger geophysical system?

SYSTEMS REMINDER: A useful boundary depends on what we are trying to understand. The same evidence may look different when we change scale. A local change is evidence to investigate - not automatic proof of space weather.

TWO RECURRING QUESTIONS

How do we learn to see what cannot be seen?

How do we know whether what happened here is part of something bigger?

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From Our Place to the Sun-Earth System

START LOCAL. THEN ZOOM OUT.

The locality of a MakerPlace magnetometer is an instructional strength. Our instrument gives us a measurement from our place. To understand whether a change is local or part of something larger, learners need evidence through time, evidence from other places, and evidence from other kinds of observations.

ONE MEASUREMENT What happened at this moment?	**CHANGES THROUGH TIME** What changed, how fast, and for how long?	**OUR PLACE** Is the pattern typical here? Could something local affect the sensor?	**OTHER PLACES** Did other communities observe something similar?
REGIONAL PATTERNS Where was the change seen, and did timing differ?	**OTHER EVIDENCE** What do auroral and space-weather observations add?	**EZIE** What different part of the system can the mission observe?	**SUN-EARTH SYSTEM** How might the evidence fit together?

WHY A NETWORK MATTERS: BUILDING A PICTURE

Think of each magnetometer measurement as a pixel in a picture. One pixel tells us something about one place at one moment, but it cannot show the whole picture. Repeated measurements add information through time. Measurements from many MakerPlace communities add information across space. Together, the network helps learners investigate where a change occurred, whether it was widespread, and how it differed from place to place.

One magnetometer tells us what happened here. A network of magnetometers helps us investigate what may be happening across the larger system. The value of the network depends on instruments collecting well-timed, well-documented, comparable measurements and communities sharing those measurements with one another.

TIME IS AS IMPORTANT AS PLACE

- Did two instruments see a change at approximately the same time?
- Did one location change before another?
- Did an auroral observation occur before, during, or after the magnetic change?
- What did EZIE or other observations show at that time?
- Does the order and timing of events strengthen a proposed relationship, or show that we need another explanation?

A QUESTIONING SEQUENCE FOR MAGNETOMETER DATA

OBSERVE	What do you notice in our local data?
ESTABLISH BACKGROUND	What seems typical or relatively quiet for this place and time?
LOCATE CHANGE	Where does the pattern change?
LOCATE IN TIME	When did it happen, and how long did it last?
CHECK LOCAL CONDITIONS	Could movement, magnets, vehicles, electrical equipment, or an instrument issue have affected the measurement?
COMPARE	Do we see a similar pattern at another time or place?
CONNECT EVIDENCE	What was happening in auroral, space-weather, or other observations around that time?
REPEAT / TEST	Does the pattern repeat? Can we find independent evidence that supports it?
INTERPRET	What might the combined evidence be telling us?
SCIENTIFIC HUMILITY	What can we not yet conclude?
NEXT QUESTION	What additional evidence would make our explanation stronger?

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Putting Different Pieces of Evidence Together

DIFFERENT INSTRUMENTS SEE DIFFERENT PIECES OF THE SYSTEM

More evidence does not mean more copies of the same information. Different observations reveal different parts of a connected Sun-Earth system. The scientific work is to place those pieces side by side and ask how well they fit together.

EVIDENCE SOURCE	QUESTION IT CAN HELP US ASK
Local magnetometer data	What changed in the magnetic field at our location?
Place and time	Where and when did the change occur? How long did it last?
Other MakerPlace / regional magnetometers	Was a similar change seen elsewhere? At the same time?
Local site observations	Was the sensor moved? Were vehicles, magnets, electrical equipment, or other local influences nearby?
Auroral observations	What was visible, where, and when?
Space-weather information	What else was occurring in the Sun-Earth environment?
EZIE observations and mission data	What different perspective from near-Earth space can help us investigate the physical processes involved?
Living systems and technology	Where else might geomagnetic conditions matter?

THEN ASK: WHAT PATTERNS APPEAR ACROSS THE EVIDENCE?

Pattern does not automatically mean cause. Help learners use evidence-centered language:

- We observed...
- We noticed a relationship...
- We tested whether the pattern repeated...
- We compared what happened here with what happened elsewhere...
- We think this might mean...
- We need more evidence before concluding...

THE MAKERPLACE EVIDENCE-TO-MEANING CYCLE

LOCAL EXPERIENCE → MEASUREMENT → CHANGE THROUGH TIME → PATTERN RECOGNITION → COMPARISON ACROSS PLACE → MULTIPLE FORMS OF EVIDENCE → REPEAT / TEST → SYSTEMS THINKING → SCIENTIFIC EXPLANATION → NEW QUESTIONS

What is happening in our place? • What does our magnetometer detect? • What seems to be the background? • What changed and when? • Is it local or widespread? • Did it repeat? • What do other observations contribute? • How might the pieces interact within a larger system? • What explanation does the evidence currently support? • What should we investigate next?

THE PHYSICAL STORY TO KEEP UNDERNEATH THE QUESTIONS

Earth has a magnetic field → it changes slowly and quickly with time → some changes and how fast they occur can reflect processes in the space environment → our magnetometer records magnetic-field changes locally → measurements over time and across locations help us distinguish local effects from wider patterns → other observations and EZIE help us investigate why those changes may have occurred.

A trembling leaf can provide evidence of wind. A magnetometer trace provides measured evidence of changes in the magnetic field at our place. EZIE provides another perspective on the larger system.

MakerPlace helps seekers bring those pieces together - from their place outward - to ask questions, recognize patterns, test ideas, and build meaning.

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From a Working Instrument to Trustworthy Evidence

OPERATIONAL READINESS IS PART OF THE SCIENCE

Before learners interpret a pattern, they need confidence that the instrument was operating as intended. Assembly, placement, orientation, timing, connectivity, and site conditions all shape the quality of the evidence. A surprising trace is therefore not automatically a space-weather event; it is an invitation to check the instrument, the site, the timing, and other observations before proposing an explanation.

READINESS CHECK	QUESTION TO ASK BEFORE INTERPRETING DATA
POWER & STATUS	Is the EZIE-Mag powered and are its components reporting normally? Use the instrument status and diagnostics before interpreting unusual data.
GPS & TIME	Has the GPS acquired a lock so location and time are reliable? Timing is essential when comparing observations across communities and with other evidence.
ORIENTATION & STABILITY	Is the magnetometer consistently oriented and left undisturbed? Record any movement, relocation, or change in setup.
LOCAL MAGNETIC ENVIRONMENT	Could phones, magnets, vehicles, electrical equipment, wiring, metal objects, or other nearby sources have influenced the measurement?
TEMPERATURE & PROTECTION	Is the instrument protected from direct weather and large temperature swings while remaining in a suitable measurement location?
CONNECTIVITY & ACCESS	Can the team reach the instrument interface—through the EZIE-Mag hotspot or the same local Wi-Fi network—to check status and retrieve data?
DATA STEWARDSHIP	Are archived data being retrieved regularly and uploaded to the EZIE-Mag site so observations can become part of the larger shared dataset?

A SIMPLE DATA ROUTINE

1. CHECK — Confirm power, component status, GPS/time, and instrument stability.
2. OBSERVE — Look at the latest data before deciding what it means.
3. DOCUMENT — Note date, time, location, setup changes, local activity, or anything unusual near the sensor.
4. ARCHIVE & SHARE — Retrieve the new archived data regularly and upload it to the EZIE-Mag site for shared use.
5. COMPARE — Place the local trace beside measurements from other times, places, and evidence sources.
6. QUESTION — Ask whether the pattern is local, repeated, widespread, or still uncertain.

FROM LOCAL DATA TO NETWORK EVIDENCE

A MakerPlace magnetometer becomes more scientifically powerful when its observations can be compared with observations from other places. That requires more than collecting data: communities need shared timing, careful site notes, regular data retrieval, and communication. When several stations observe a similar change at approximately the same time, the network can investigate how widespread it was and how its shape, magnitude, or timing differed by location. When only one station sees a change, that is useful evidence too—it prompts investigation of local conditions, instrument behavior, or a genuinely localized phenomenon.

MAKERPLACE NETWORK PRACTICE

For collaborative investigations, each community should be prepared to share a clearly identified interval of data together with the place, date/time, and relevant site observations. The goal is not for every graph to look the same. The goal is to use differences and similarities across the network to generate better questions and stronger evidence.

A useful network question:

Did something change here—and what do measurements from other places and times help us understand about it?

FIELD GUIDE REMINDER

The assembly instructions and EZIE-Mag website provide the technical procedures for building, configuring, diagnosing, retrieving, and uploading data. This Field Guide uses those operational practices as part of evidence-centered learning: reliable instruments + documented context + shared observations make stronger scientific questions possible.