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Developing Primary Data Literacy through Environmental STEAM Investigations

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Abstract: Environmental projects can provide meaningful settings for primary data literacy, but collecting measurements does not automatically support sound interpretation. This conceptual article proposes a STEAM investigation in which pupils connect a question, a measurement rule, a digital representation and a bounded design decision. The GAISE II framework, engineering-design standards, digital-competence literature and formative-assessment theory inform the analysis. The resulting design uses observations of light and shade in a school setting without requiring personal pupil data. It separates observation from inference and identifies how recording conventions, missing entries and chart design affect a conclusion. A classroom sequence and evidence matrix illustrate the proposal. No environmental dataset or pupil attainment results are reported. The contribution is an instructional framework for teaching about the digital world through the construction and interpretation of data, with explicit limits on causal claims and generalisation. Classroom feasibility and learning effects require subsequent empirical study.

Keywords: data literacy; primary education; STEAM; environmental inquiry; data visualisation; evidence-based reasoning.

1 Introduction

Children encounter charts and numerical claims in learning materials and everyday digital media. Producing a colourful graph is not sufficient preparation for interpreting those claims. Pupils also need to understand what was observed, how observations were recorded and which conclusions the data can support. An environmental investigation can make those questions concrete because the class can inspect the setting that gives the values meaning.

The GAISE II report organises statistical problem solving around an investigative question, data, analysis and interpretation [1]. This provides an appropriate starting point for a project in which digital representation is connected to an answerable question. The aim is not to accelerate formal statistics beyond primary readiness. It is to make the reasoning behind a small dataset visible.

The research question is how an environmental STEAM project can develop primary data literacy while retaining clear boundaries between measurement, representation and inference. The article proposes a question-to-decision sequence and a worked design involving light and shade. Its focus is evidence in environmental reasoning, rather than programming instruction or a comparison of national curricula.

2 Materials and methods

The study uses conceptual design analysis. GAISE II supplies a statistical-education reference [1], the grades 3–5 engineering-design standards provide a basis for considering criteria and constraints [2], DigComp 2.2 supplies a digital-competence reference [3], and Black and Wiliam's account of formative assessment informs the proposed use of evidence to guide instruction [4]. Selection was purposive and does not support claims of exhaustive literature coverage.

The design procedure first identifies an environmental question that pupils can investigate safely. It then specifies what counts as one observation, how records can be checked and what representation fits the question. Finally, it identifies a decision that could reasonably be informed by the evidence. Each step is checked for a possible overclaim, including unjustified causal explanation or generalisation beyond the observed setting.

No school investigation was conducted. All tasks, recording formats and response examples are author-generated proposals. The article presents no measured light levels, pupil scores or comparisons between classes. Any later study would need an appropriate school approval process, accessible task materials and a documented measurement procedure.

3 Results

3.1 An answerable environmental question

The proposed class project asks which of two supervised outdoor locations provides shade during a specified school period. The question is deliberately narrower than asking which place is healthiest or best for every activity. Pupils decide how to record the visible condition and identify factors that could change across observations, including time and weather. A teacher selects safe locations and supervises any visit.

A simple version records whether a marked area is shaded, partly shaded or unshaded at agreed times. An optional extension uses a suitable measuring device, but its readings introduce questions about units, placement and calibration. These versions should not be treated as producing equivalent evidence. A categorical record answers a different question from a numerical measurement of illuminance.

The STEAM connection follows the investigative need. Science concerns observation of environmental conditions. Mathematics concerns categories, comparison and variability. Technology concerns storing and representing the record. Engineering concerns designing a proposal within constraints, such as movable materials or available space. The arts concern a clear visual explanation for the intended classroom audience.

Table 1. Proposed question-to-decision sequence

Stage	Pupil action	Reasoning to make explicit
Question	Specify location, condition and time	What exactly are we trying to know?

Record	Use an agreed observation rule	Would another observer record the same case?
Check	Inspect missing or inconsistent entries	What can be corrected without inventing data?
Represent	Choose a chart suited to the record	What comparison does this display make visible?
Interpret	State a conclusion and its boundary	What does the record not tell us?
Design	Propose a feasible response	How does the evidence support this choice?

3.2 Recording conventions and data quality

Before collecting observations, pupils examine fictional sample entries. One entry has no time, another uses a different category word and a third is blank. They discuss whether the problem is a missing observation, inconsistent notation or an unclear rule. The purpose is to teach that data quality begins before a chart is created. Software cannot recover an observation that was never made.

A recording sheet contains only what the question needs: location code, date or session, time category, observation and a brief relevant note. It does not require children's names, home details or photographs of identifiable people. Environmental images, if used, should be framed to avoid unrelated personal information. Reducing unnecessary data also makes the investigation easier to explain.

Missing entries remain visibly missing. Pupils should not substitute a convenient value to make the graph complete. If a record can be checked against an original note, the correction and its reason are retained. Otherwise the class discusses how the absence limits the conclusion. This introduces uncertainty as part of ordinary investigation rather than as a failure to produce a neat result.

3.3 Digital representation as a design decision

Pupils first organise a small record with cards or a paper table. They then produce a teacher-supported digital representation using the same entries. The comparison asks what has changed: the underlying observations or their presentation. A digital chart can improve readability while still using incorrect labels or an unsuitable scale. Checking the data and checking the display are therefore separate actions.

For categorical shade records, counts by category may be more appropriate than a line implying a continuous quantity. If the task instead records repeated numerical measurements, another representation may be justified. The teacher should connect the choice to the question and data type, avoiding a rule that one chart format is always best. Decorative features are evaluated for whether they help or obscure comparison.

Table 2. Proposed evidence matrix

Learning focus	Evidence product	A diagnostic question
Observation rule	A definition of the categories	How would you classify a borderline case?
Record integrity	A checked table	Why is this entry still blank?
Representation	A labelled display	Do the labels describe the recorded quantity?
Interpretation	A bounded written or oral statement	Does this apply beyond the observed period?
Design justification	A proposal linked to evidence	Which observation supports the decision?

The matrix is not a validated rubric. It identifies different evidence needs so that a polished display does not replace investigation. An individual explanation can be collected alongside the group product. Where language support is provided, the teacher records whether it clarified the question or supplied the substantive reasoning.

3.4 From findings to a bounded design proposal

After interpretation, pupils may propose a small classroom display recommending a suitable location for a defined activity at the observed time. They state the criterion, the evidence and a limitation. A proposal to move a portable reading mat differs from a claim about permanent building work. The scale of the decision should remain proportionate to the modest dataset.

An alternative explanation prompt asks whether the result could change on another day. Pupils identify what further observation would be needed. They need not calculate formal confidence intervals. A statement such as “our record covers only these sessions” demonstrates an important boundary. It is more defensible than presenting the class record as proof of a universal environmental relationship.

4 Discussion

The project makes digital literacy inseparable from the provenance of a representation. Pupils are not simply learning where to click to create a chart; they are learning how an observation becomes a stored record and a claim. DigComp 2.2 includes information and data literacy [3], but the present activity samples only a limited part of that domain. It does not establish broad online information-evaluation competence.

GAISE II emphasises variability and the connection between questions and interpretation [1]. The proposed shade investigation applies that orientation without reproducing the report’s examples. Its suitability depends on the local environment and supervision. Where outdoor access

is impractical, a teacher can use a clearly identified prepared dataset, while acknowledging that pupils are then analysing supplied observations rather than collecting their own.

Engineering enters when pupils consider a response under criteria and constraints [2]. A design recommendation should not be confused with a scientifically proven optimum. The class may have several reasonable proposals, each balancing different needs. Pupils should explain the balance rather than assume that a single graph mechanically determines a decision.

Formative assessment requires using evidence to decide a next instructional move [4]. In this project, a missing unit suggests different teaching from an unsupported generalisation. A short teacher comment should identify the issue and invite revision. Merely assigning a score to the completed poster would not provide the same guidance about observation, representation or inference.

The framework has not been tested. Future research should examine whether pupils preserve the meaning of observations when moving to a digital display and whether they can state the scope of a conclusion. Data about task completion alone would be insufficient. Classroom studies should document reading demands, teacher intervention, access to devices and the distinction between individual and group reasoning.

5 Conclusion

Environmental STEAM investigations can be designed to connect an answerable question with recording, checking, representation and a proportionate decision. The proposed sequence foregrounds the limits of evidence as well as the production of digital artefacts. It offers a conceptual route for primary data literacy, not proof of learning effectiveness. Local trials are needed to establish its feasibility and educational value.

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