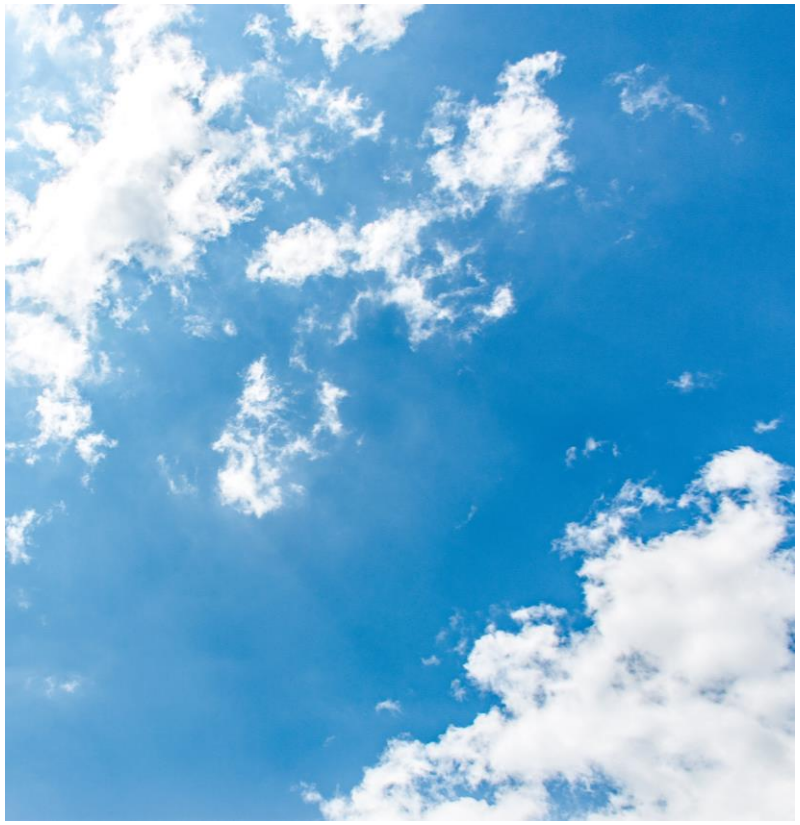
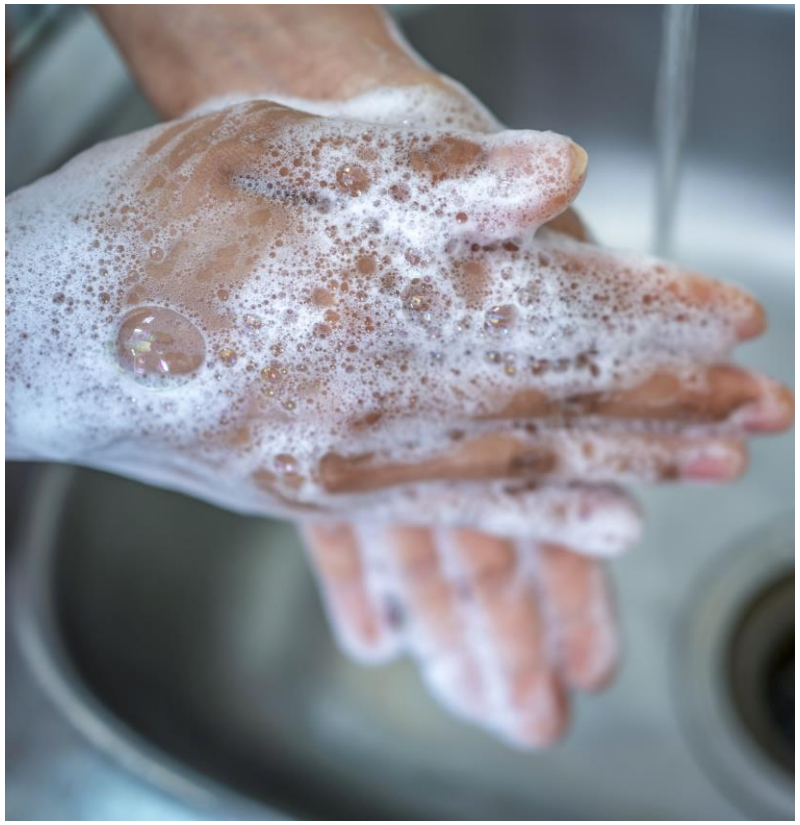




Scientific explanation

UiO : Department of Teacher Education and School Research
University of Oslo

Leveraging log data to examine students' progression in constructing scientific explanation

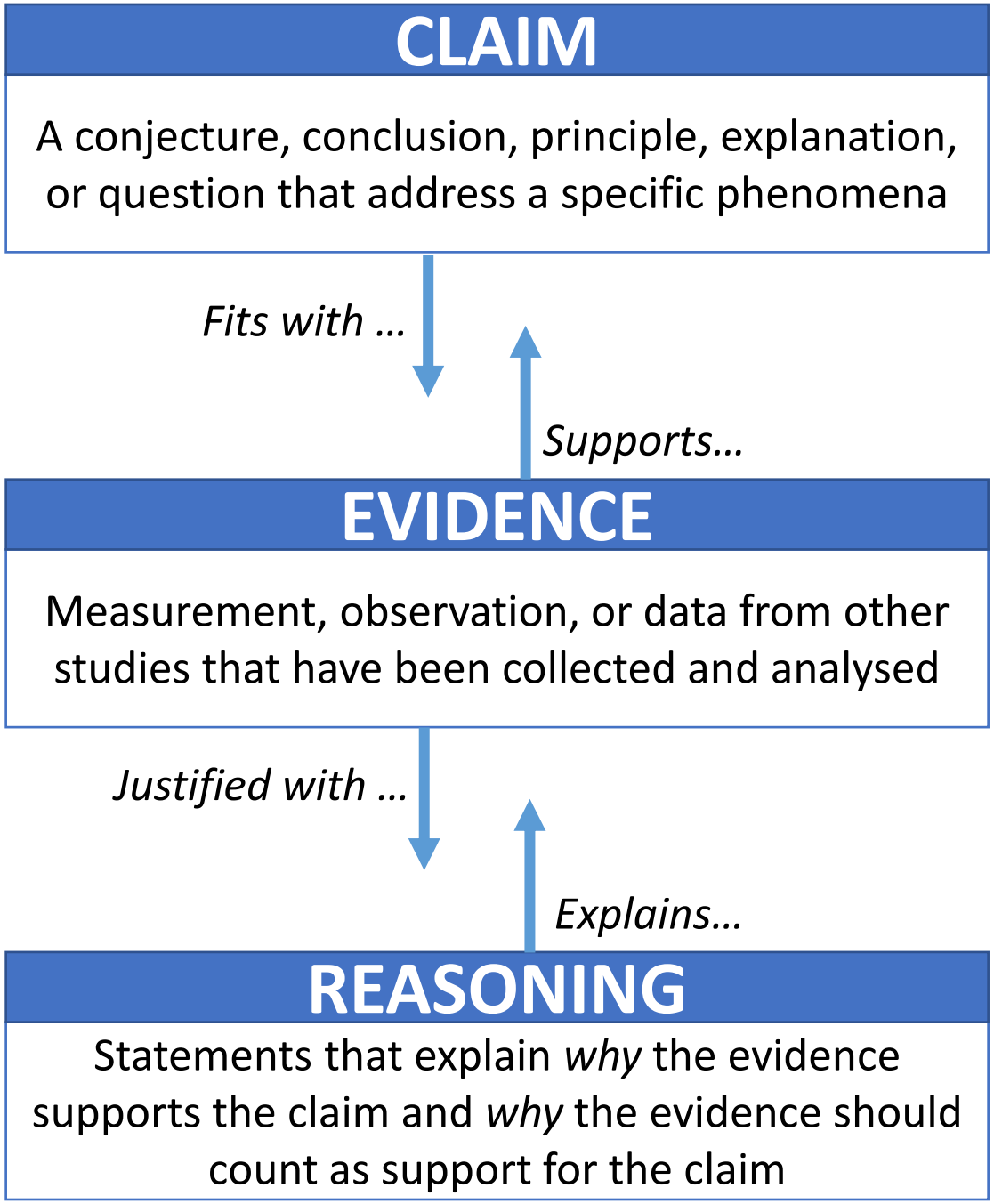
Nani Teig and Fredrik Jensen

University of Oslo, Norway

Beyond Results 2021, 30 Sep-1 Oct 2021

Background

- The role of explanations in science: *what we know, why it happens, and how we know* (Rocksén, 2016).
- The role of explanations in science education:
  - understand science content
  - understand the nature of science
  - promote critical thinking and scientific literacy (Duschl & Osborne, 2002; McNeill & Krajcik, 2011).
- Scientific explanation plays an integral role in science education reforms around the world.



Scientific explanation

Phenomenon

Question about the natural world

McNeill & Krajcik (2011); Sampson & Gerbino (2010); Osborne, Eruduran, & Simon (2004); Yao, Guo, & Neumann (2016)

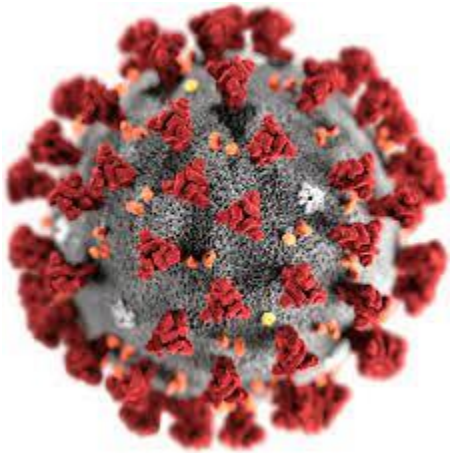
CLAIM

Handwashing with soap is an effective tool to prevent the spread of coronavirus

Scientific explanation

Phenomenon

Handwashing



CLAIM

Handwashing with soap is an effective tool to prevent the spread of coronavirus

Fits with …

Supports…

EVIDENCE

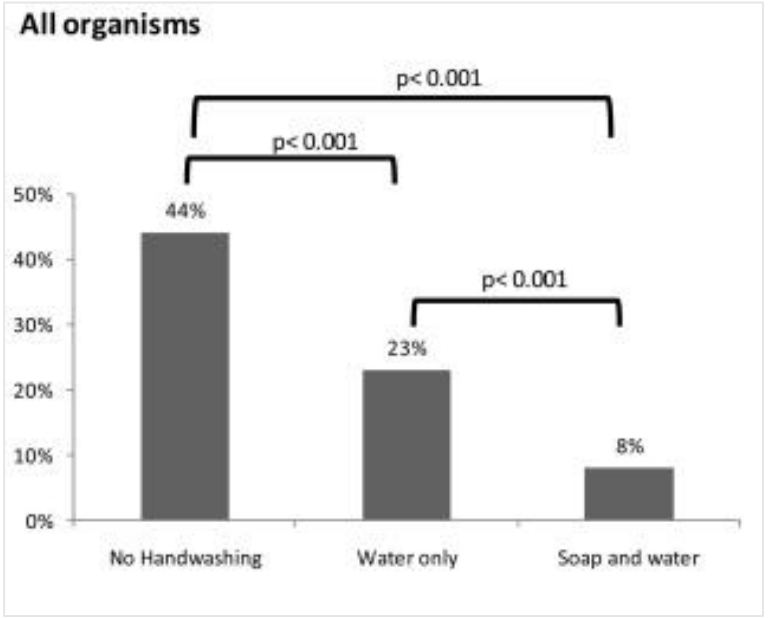
Data from observation, experiment, or existing studies

Justified with …

Explains…

REASONING

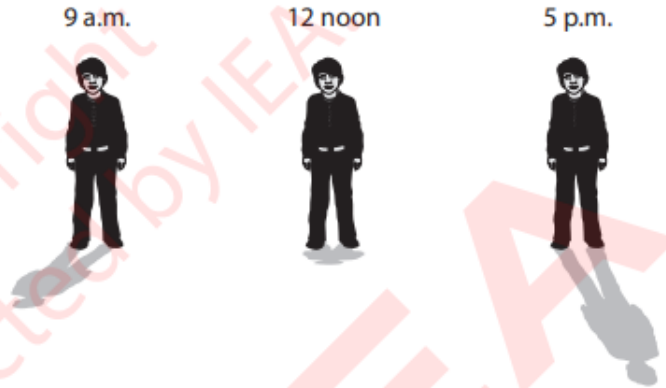
Germs including coronavirus can spread through contact. Handwashing with soap destroy the chemical bonds and remove germs from hands.



Scientific explanation in ILSAs

IEA TIMSS 2019

The pictures below show a shadow at three different times of the day.



Explain why the shadows changed.

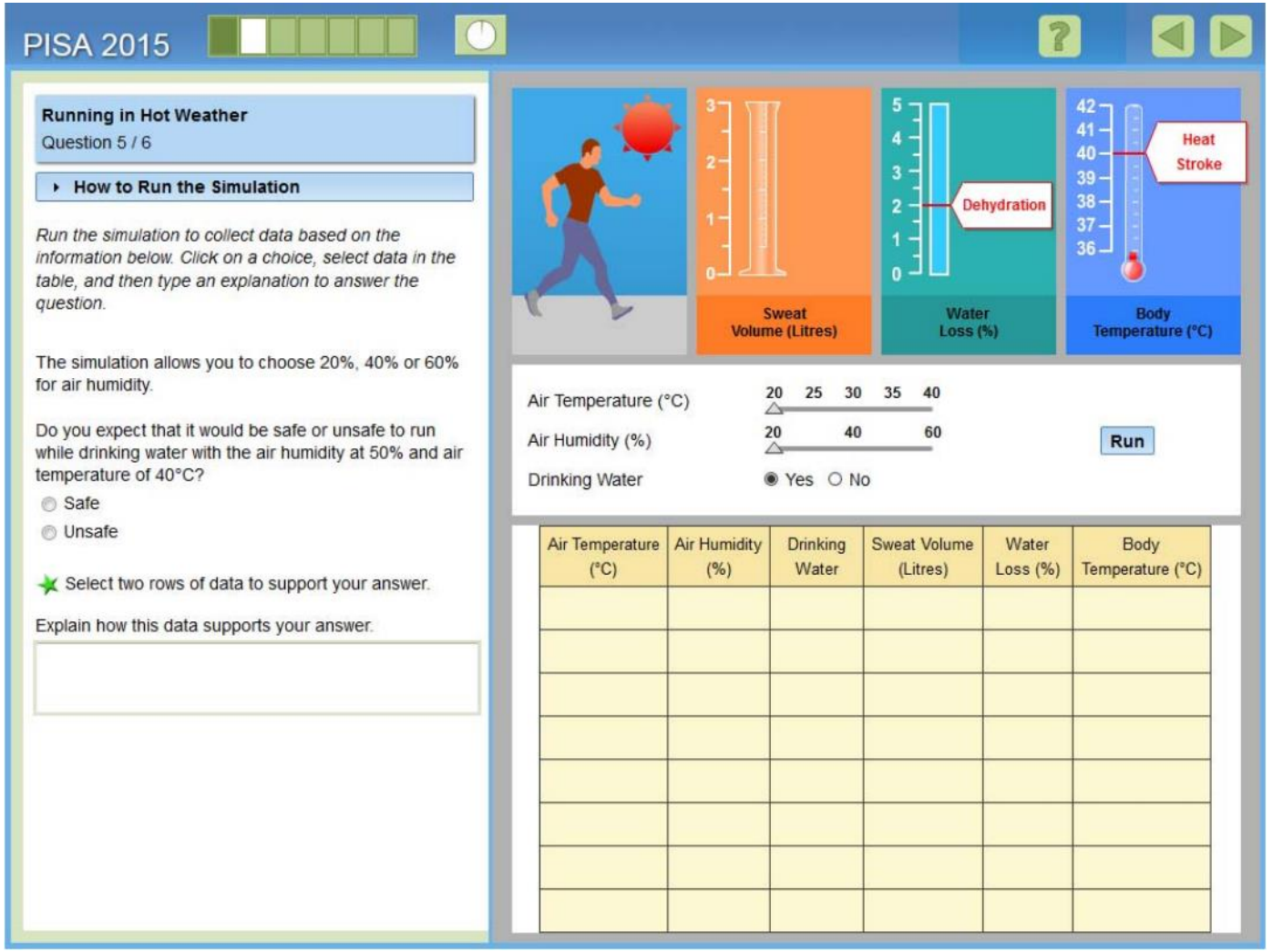
The shadows changed because the sun changed position in the sky

Scientific explanation in ILSAs

claim

evidence

reasoning



evidence

Research question

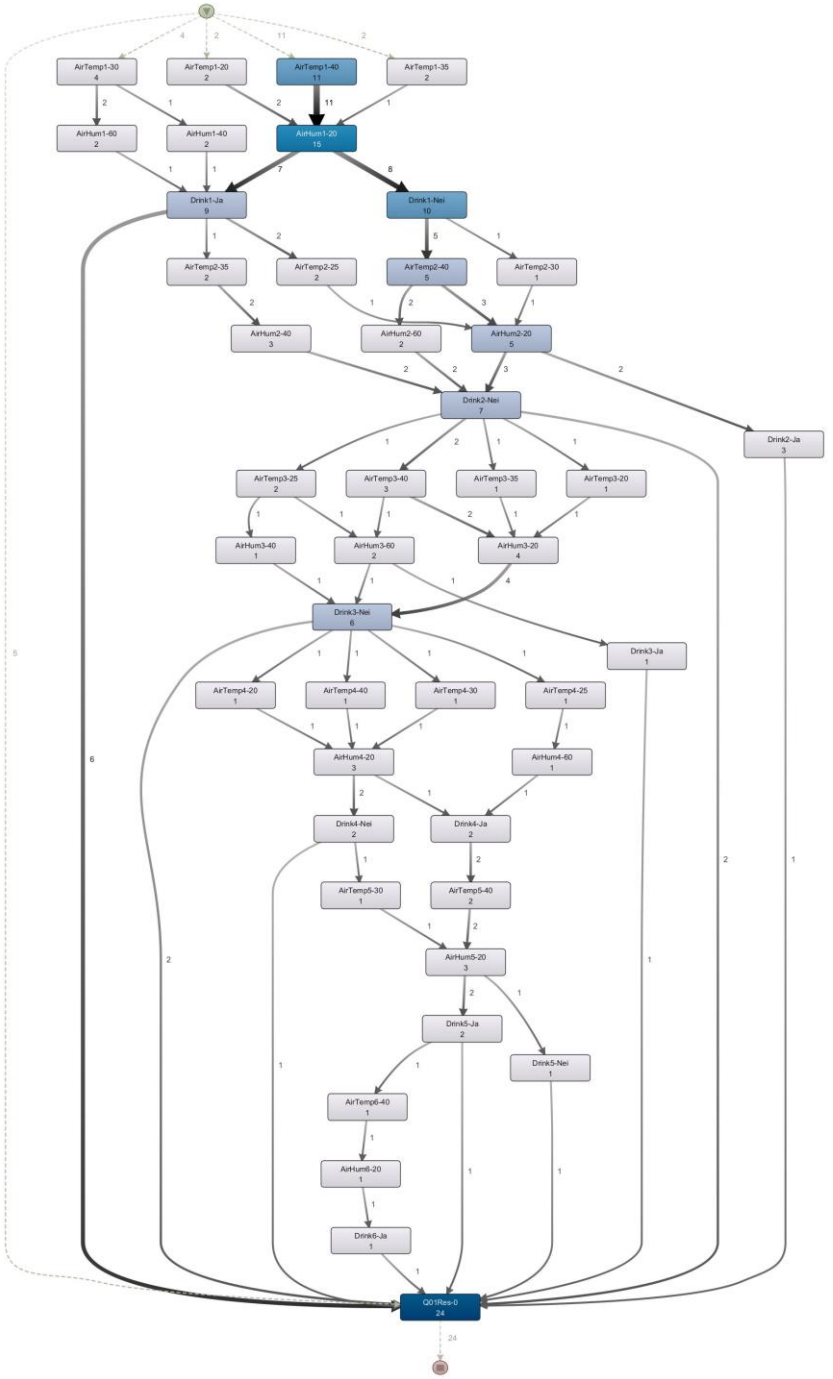
How do students construct scientific explanation using simulated investigation?

Data

- PISA 2015 field trial data from Norway
- The Running in Hot Weather unit (five interactive tasks): https://bit.ly/PISA-science
- *N*=81 students (39 girls and 42 boys)

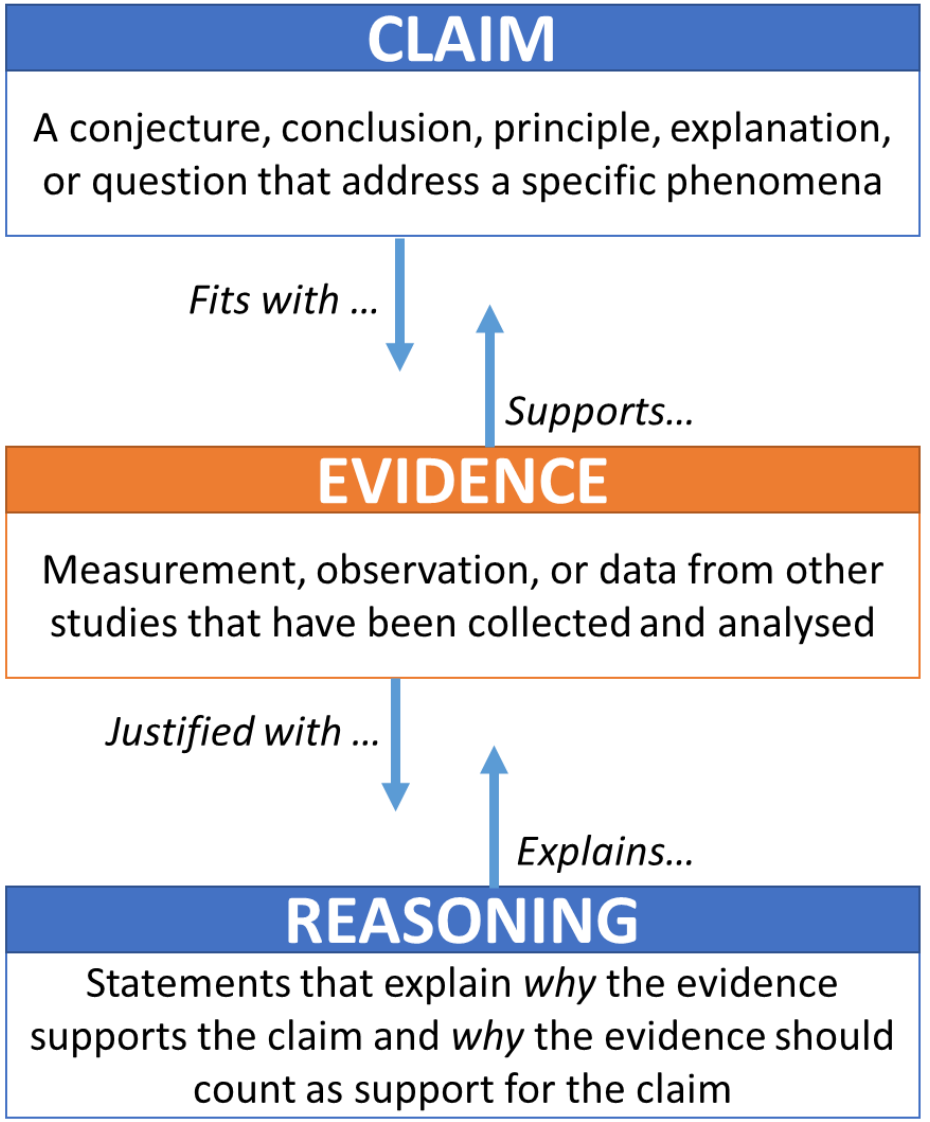
Methods

- Students' log file data
- XML files → CSV file → CER variables
- Process mining (Disco)→ to analyse students' sequence of actions to generate evidence in simulated investigation.
- Behavioural indicators



Findings

Mapping students' pattern of performance in constructing scientific explanation into a theoretical framework

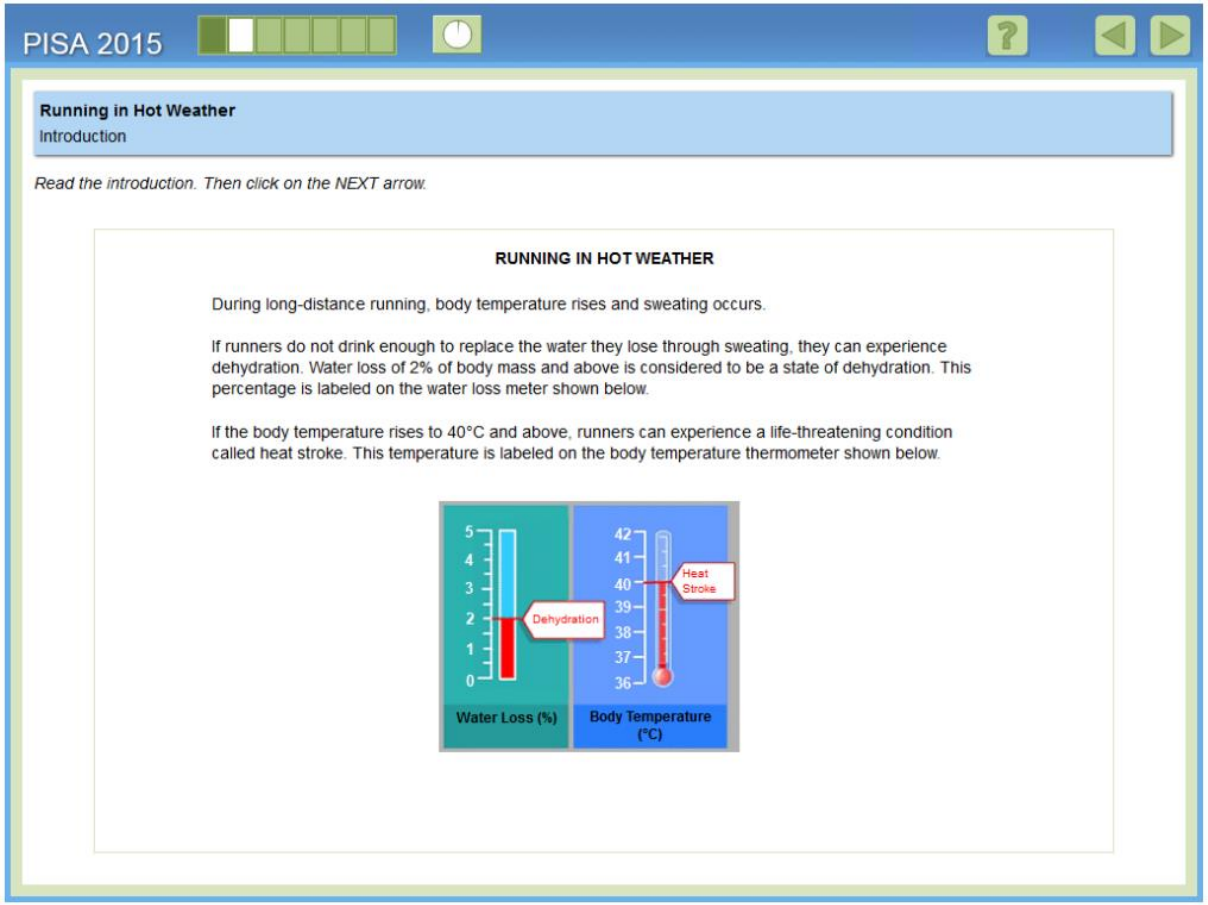


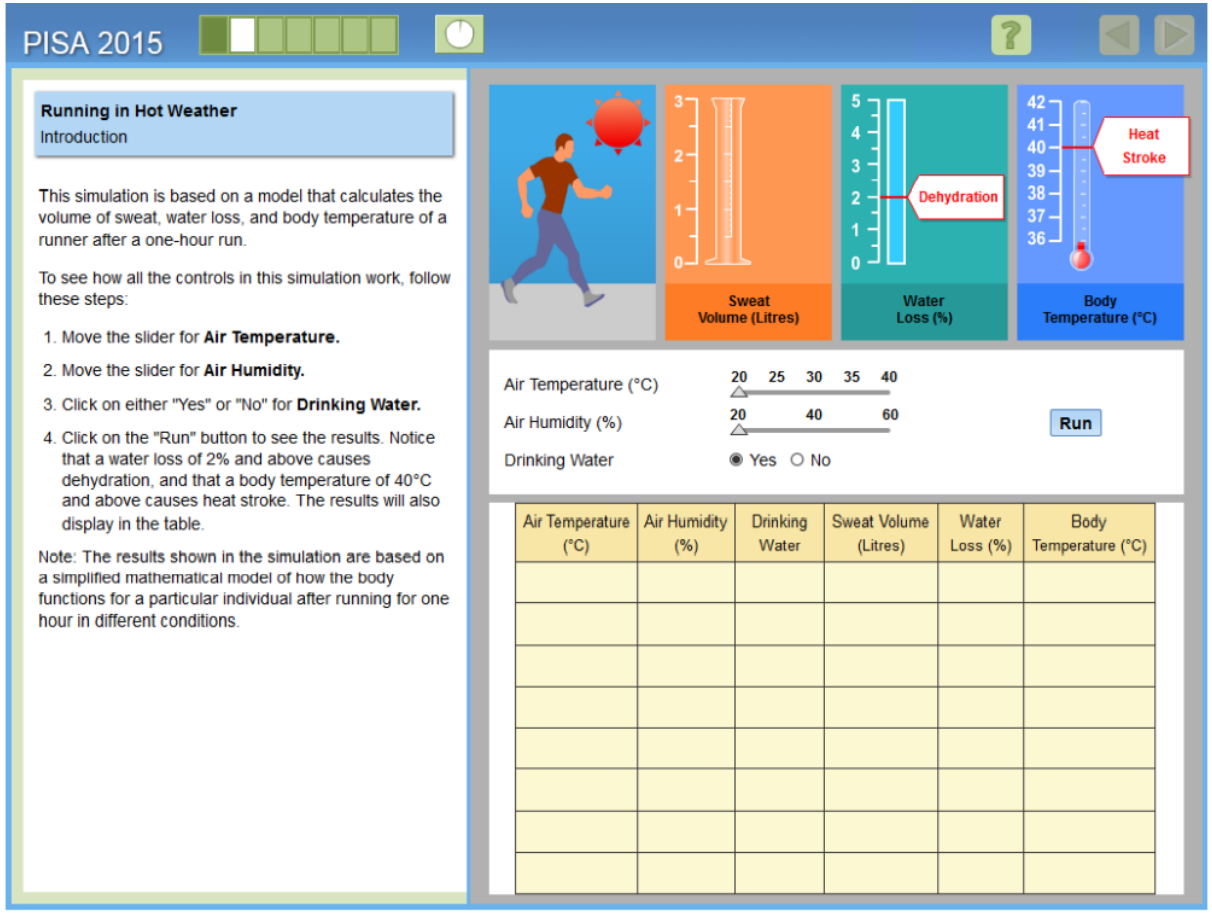
Scientific explanation (SE) framework

Yao, Guo, & Neumann (2016); McNeill & Krajcik (2011)

Components	Basic	Moderate	Complex
Claim	Affirming and describing the phenomenon. [The phenomenon is clear; it has single variable or has a few variables, but their relationship is simple; the changing pattern is conforming to everyday experience.]	Abstracting and representing the phenomenon. [The phenomenon needs processing from real context. It has several variables, and their relationship is complex; the changing pattern may not conform to everyday experience.]	
Evidence	Searching data in a small data set.	Searching data in a big data set.	Defining the data set.
	Data set is limited to appropriate data	Data set includes both appropriate/inappropriate data/non-related data set	
	Data set is ready for directly processing	Data is collected by directly observation, measurement, etc.	Data is collected by indirectly observation, measurement, etc.
Reasoning			
Domain general	Making basic logical connection between idea, data, and phenomenon, though generalization, induction, or simple causal reasoning.	Developing a causal chain or clarifying the mechanism that connecting phenomenon, evidence, and theory, though scientific reasoning including isolation and control of variables, correlational reasoning, probabilistic reasoning, etc.	Designing a unification model that connecting phenomenon, evidence, and theory, though scientific reasoning including but not limited to isolation and control of variables, combinatorial reasoning, probabilistic reasoning, hypothetical-deductive reasoning, etc.
Domain specific	Applying scientific ideas, law-like sentences, etc. under the scaffold from teacher or instructional materials.	Using the key variable as the clue for independently selecting scientific concepts, laws, theories, and principles.	Independently selecting the scientific concepts, laws, theories, and principles by systematically analysing the context.

Running in Hot Weather unit: Introduction





https://bit.ly/PISA-science

Stage 1: Basic SE

Claim

Identify the phenomenon that needs explaining

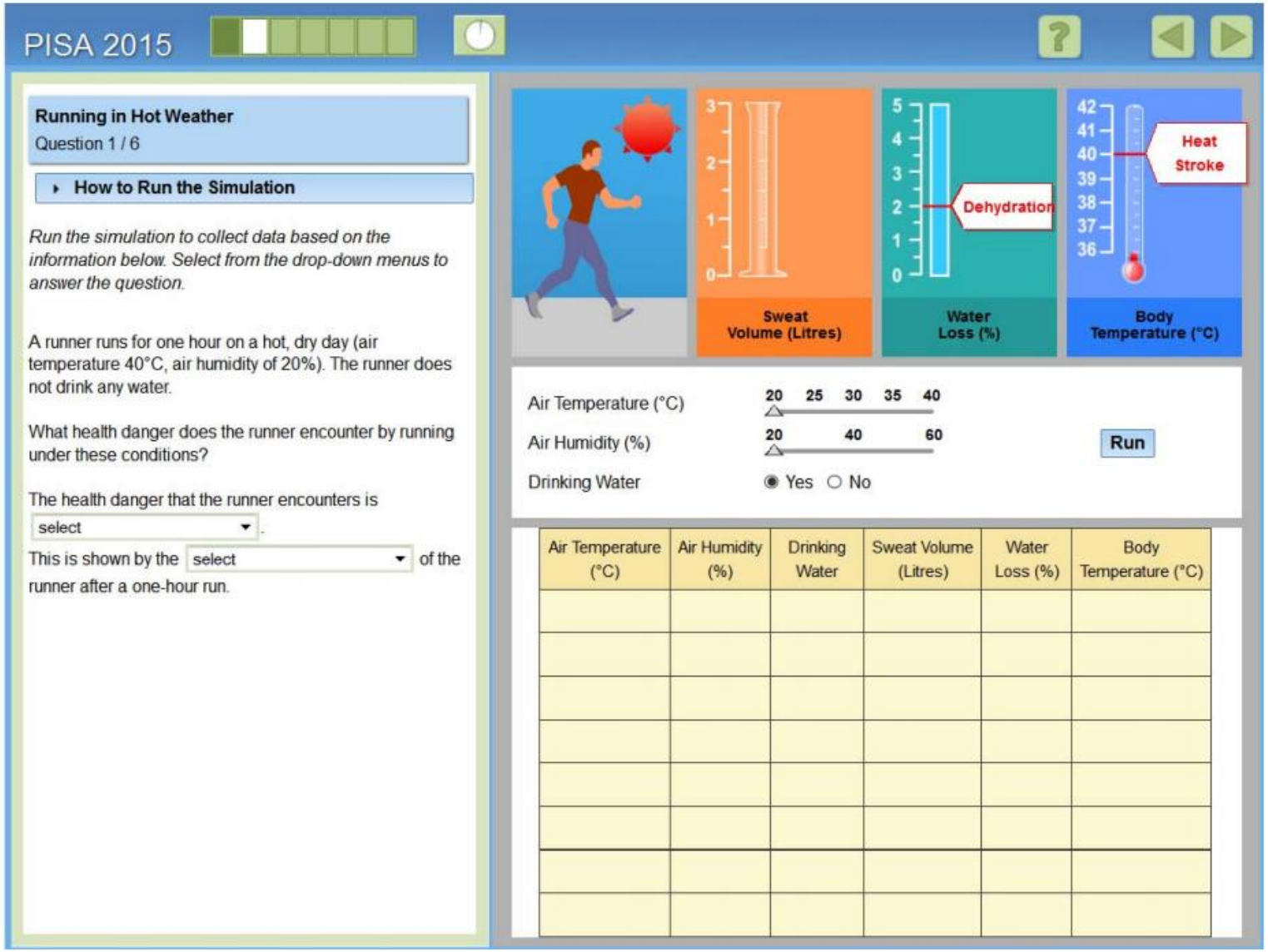
Evidence (not scored)

- Searching data in a small data set.
- Data set is limited to appropriate data

Reasoning

Making basic logical connection between phenomena and data

Unit 623 *Running in Hot Weather*
Released Item #1



https://bit.ly/PISA-science

Stage 1: Basic SE

Claim

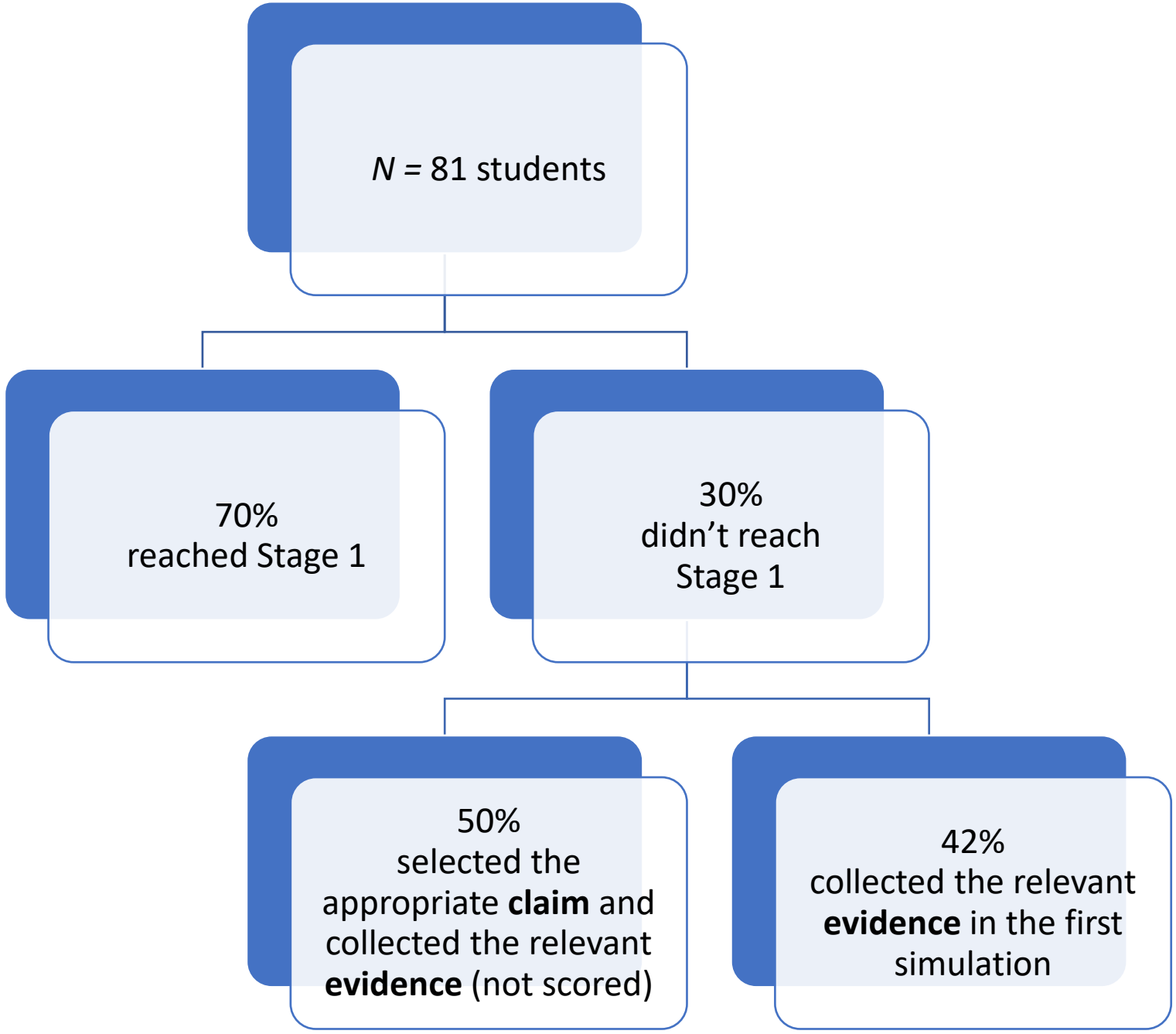
Identify and describe the phenomenon that needs explaining

Evidence (not scored)

- Searching data in a small data set.
- Data set is limited to appropriate data

Reasoning

Making basic logical connection between phenomena and data



Stage 2: Moderate SE

Claim

Identify and describing the phenomenon

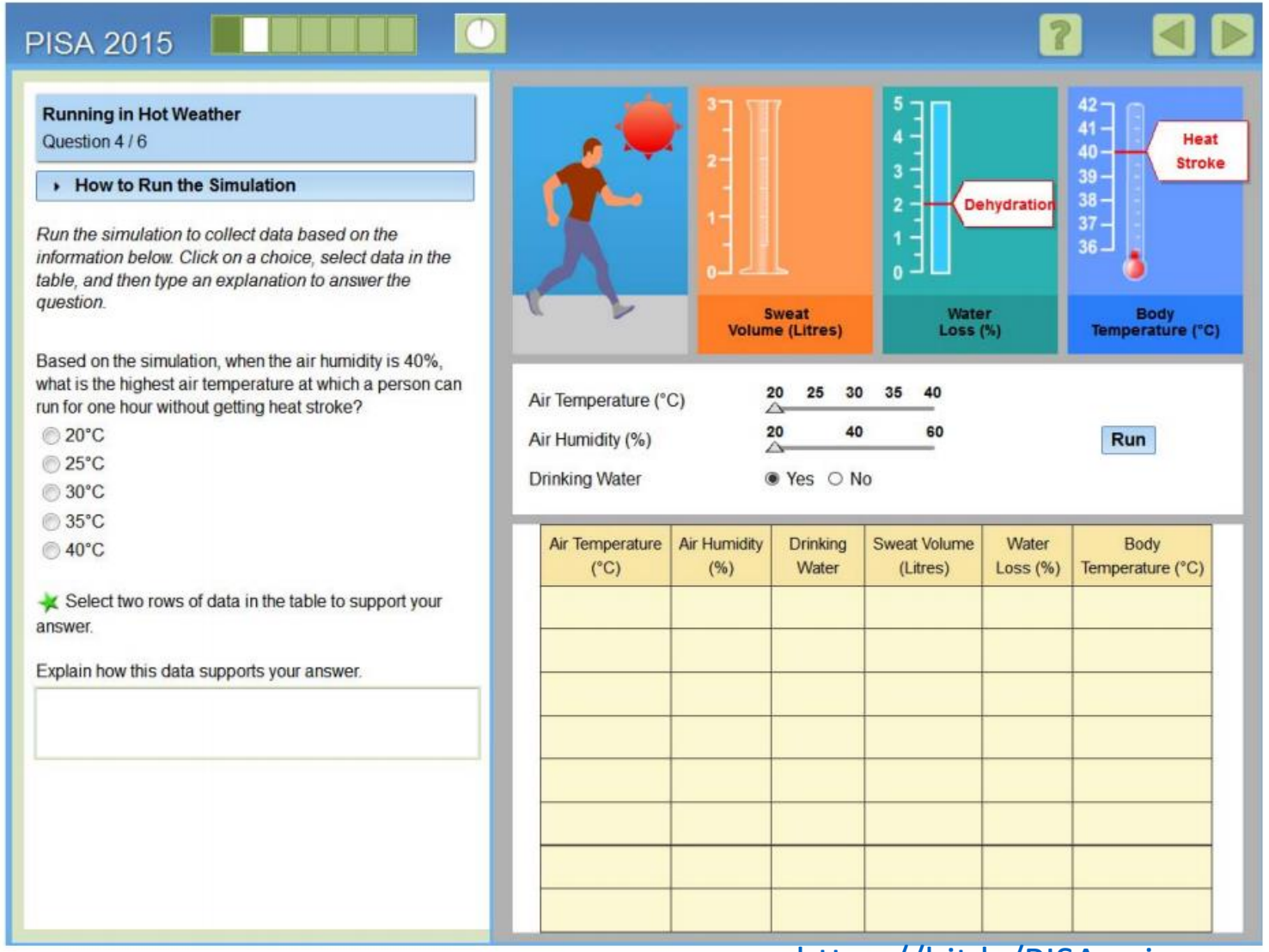
Evidence

- Searching data in a small data set.
- Data set is limited to appropriate data

Reasoning

- Using basic scientific reasoning (appropriate isolation and control of variables)
- Developing a causal chain that links phenomenon and data

Unit 623 *Running in Hot Weather*
Released Item #4



https://bit.ly/PISA-science

Stage 2: Moderate SE

Claim

Identify and describing the phenomenon

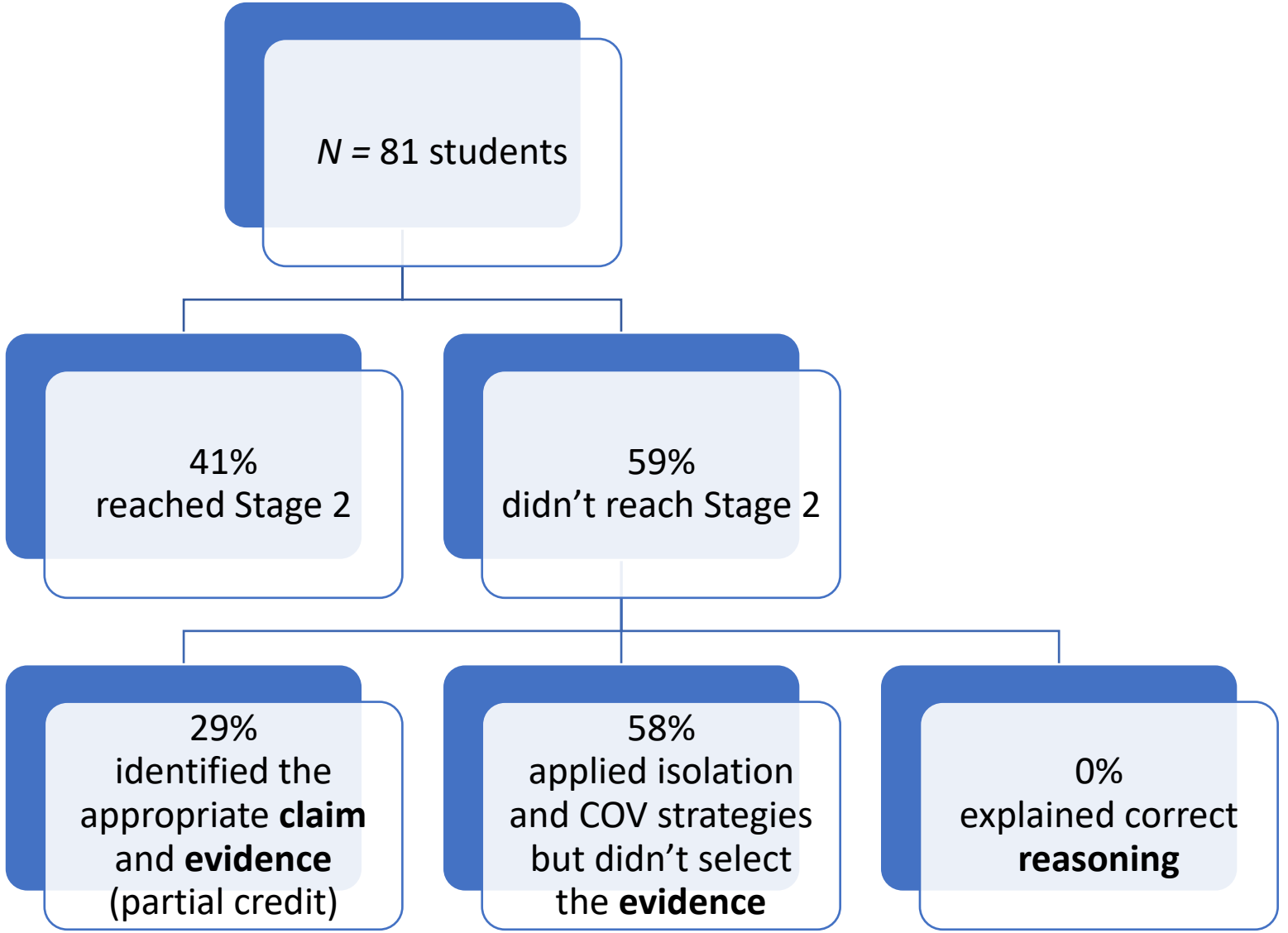
Evidence

- Searching data in a small data set.
- Data set is limited to appropriate data

Reasoning

Applying domain general reasoning (appropriate isolation and control of variables)

Developing a causal chain that links phenomenon and data



Stage 3: Complex SE

Claim

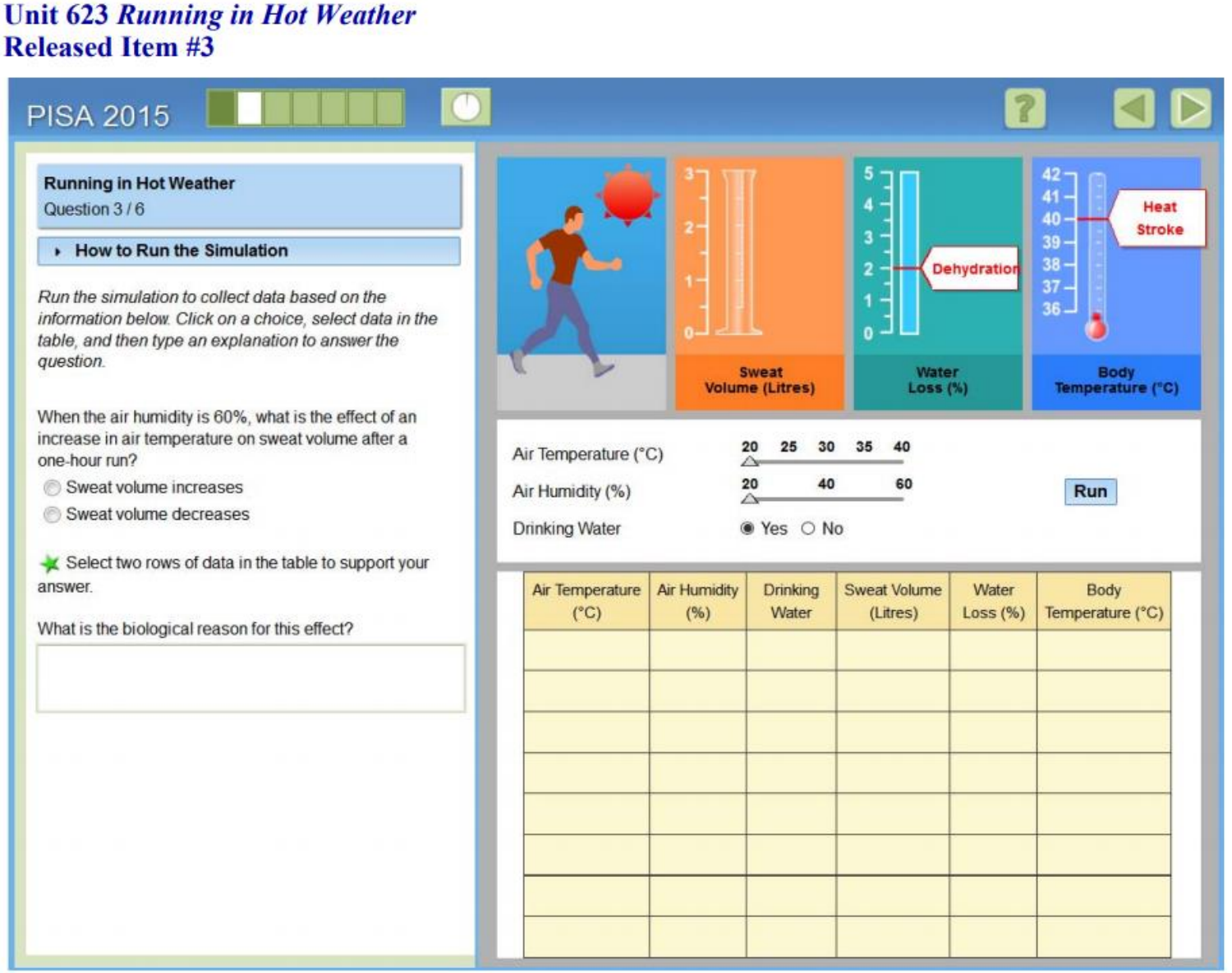
Abstracting and representing the phenomenon.

Evidence

- Searching data in a small data set.
- Data set is limited to appropriate data
- Data set includes both appropriate/inappropriate data/non-related data set

Reasoning

- Using basic scientific reasoning (appropriate isolation and control of variables)
- Developing a causal chain that links phenomenon and data
- Using the key variable as the clue for independently selecting scientific concepts, laws, theories, and principles.



https://bit.ly/PISA-science

Stage 3: Complex SE

Claim

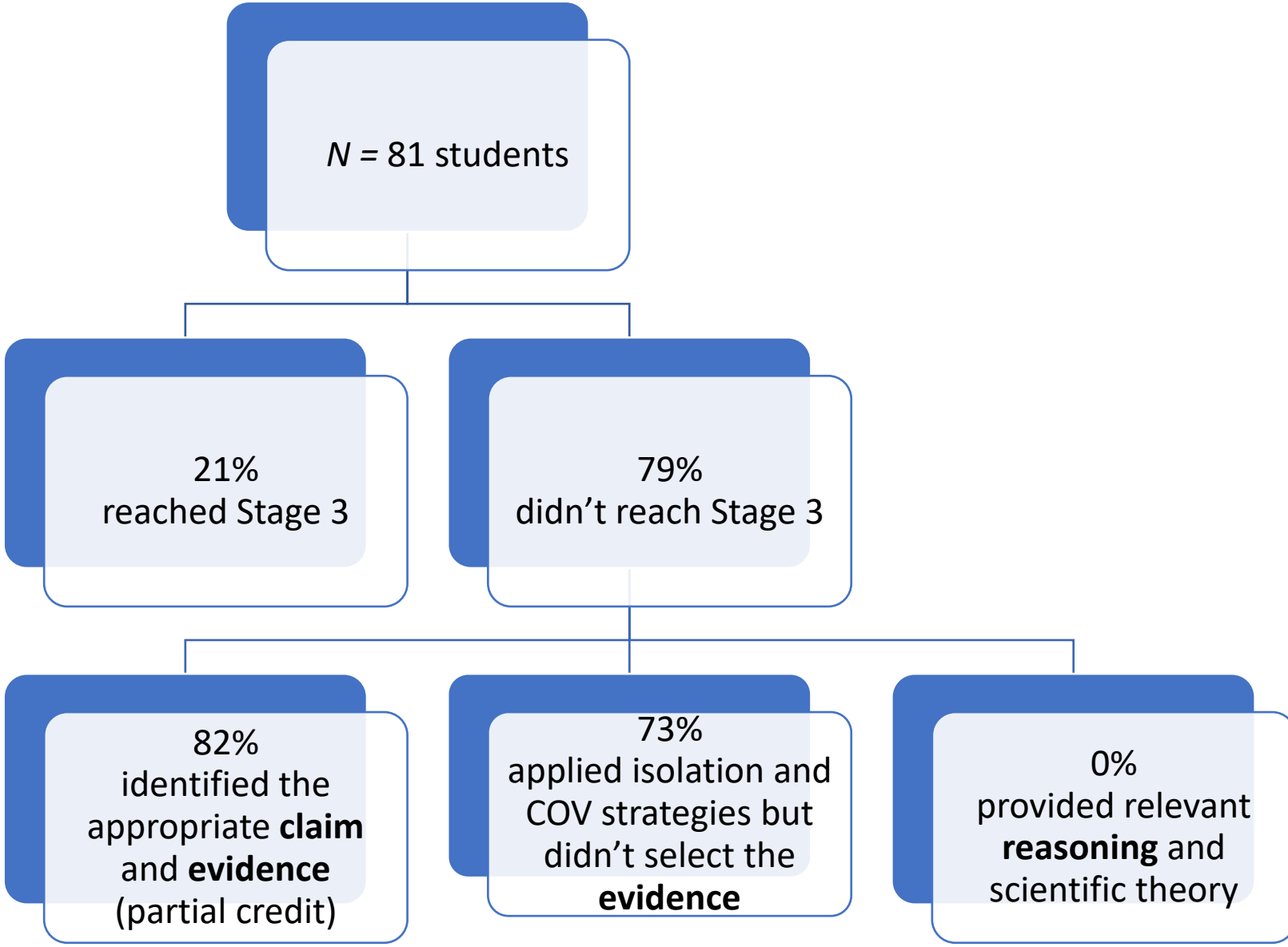
Abstracting and representing the phenomenon.

Evidence

- Searching data in a small data set.
- Data set is limited to appropriate data
- Data set includes both appropriate/inappropriate data/non-related data set

Reasoning

- Using basic scientific reasoning (appropriate isolation and control of variables)
- Developing a causal chain that links phenomenon and data
- Independently selecting the scientific concepts, laws, theories, and principles by systematically analysing the context.



Higher number of trials, time before the first action, and time-on-task

Discussion

- Challenges in constructing scientific explanation:
  - Using appropriate and sufficient evidence
  - Providing reasoning that links the evidence and claim
  - Applying scientific theories, concepts, laws, and principles
- Norwegian students had fewer opportunities to engage in inquiry-based activities compared to other countries (PISA 2015, TIMSS 2019).
- The potential of log file data in examining students' scientific explanation.