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Narrative In Science Education
Story Construction for Science Education
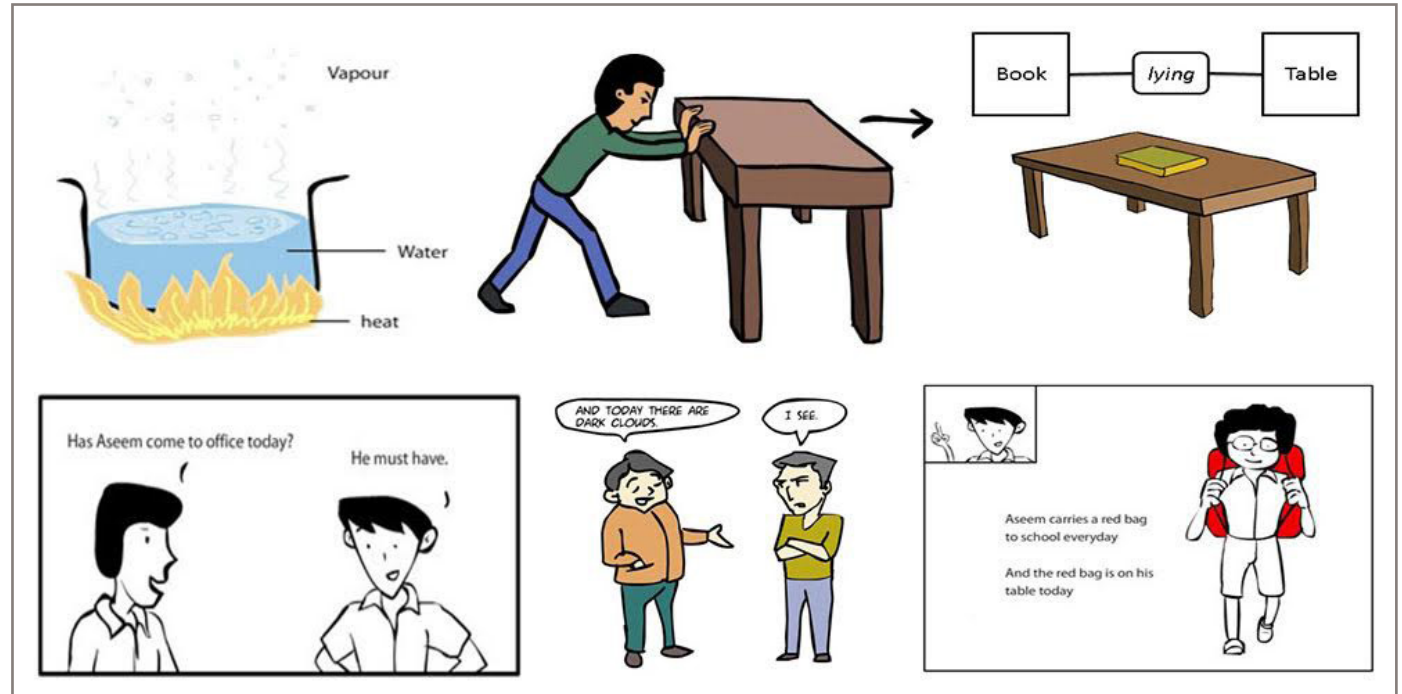by
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Introduction

• How do you read comics?
• How do you understand comics?

As a visual medium, comics are unique in the sense that they form flowing narratives through the use of a sequence of static images, often supported by text. But then, how does the reader understand the narrative in comic books? According to Scott McCloud in Understanding Comics (1993), the real message in comics lies in the space between panels, what he calls the "gutter". It is the way in which the writer/creator handles these transi-tions that eventually allows the reader greater or lesser control over the interpretation of the narrative. In other words, he calls transitions between panels the grammar of comic books.

McCloud defines six transitions from one panel to the next:

- •Moment-to-moment
- •Action-to-action
- •Subject to subject
- •Scene-to-scene
- •Aspect-to-aspect
- •Non-sequitur

Similarly, McCloud identifies words, pictures and icons as the vocabulary of comic books. For him, the "icon" is the key unit that forms this vocabulary of comics. Semiotics has long studied signs and what they signify, and McCloud applies this knowledge to form a basis for the language of comics. If we draw a parallel with linguistics (the study of language in speech and writing), where words and sentences are the basic building blocks, we can see that comics also have their own building blocks, which go beyond just words and images alone. In written and spoken language, you make meaning through words and through the structure of sentences (which is the inter-relationship between words), and this is what we call syntax and semantics in linguistic terms. But the rest of the media also have their own syntax and semantics. How do these work in the case of comics?

To answer these questions, this article, borrowing heavily from McCloud's views mentioned above, seeks to describe and present various aspects of the grammar and vocabulary of comics, supported by examples from a range of existing comics. It is hoped that his will be helpful to anyone studying comics or even, to some extent, for those studying visual narratives in general.

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In this module, the design process for making Narrative for explaining science concepts is explained.

• We know that scientific concepts are an outcome of the process of scientific inquiry performed by scientist at some time in history.

• It has been found through research in Theory of Knowledge that, 'the process of a scientific inquiry follows a particular type of Narrative structure.'

• Hence, scientific concepts can be well represented if they are explained in the form of the Narrative structure that underlies a scientific inquiry process.

• First, we will present the philosophical aspect behind the process by looking at a scientific inquiry event as a Narrative.

• Then, the structure of Science Narrative will be outlined, using which any scientific concept can be explained in the form of a Narrative.
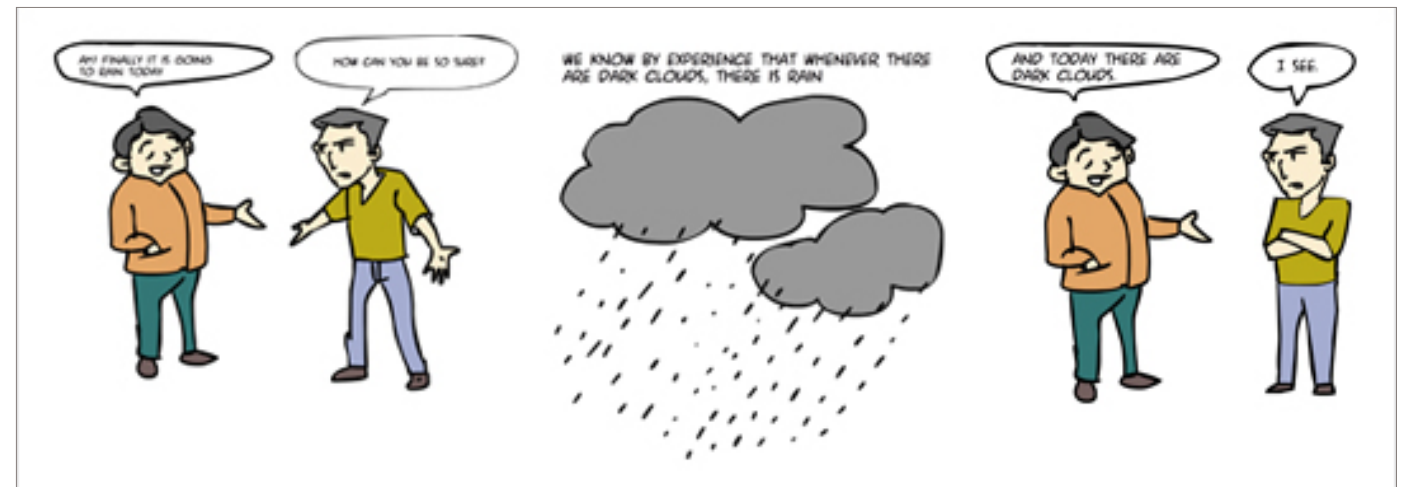
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Designing Stories

Designing Stories for Learning Science:

In recent years there has been a growing interest in the educational community towards use of Narratives in Education. Science education is one area where Narratives methods of explaining concepts are being tested.

This exercises provides an outline of the process by which a scientific concept can be explained in a narrative format.

Science is a process with a particular kind of Narrative structure. If someone has to do science, knowledge of the Narrative structure underlying a scientific inquiry event is a necessary condition to be learnt.

In the following next sections, the process for looking at a scientific concept as a Narrative is presented.
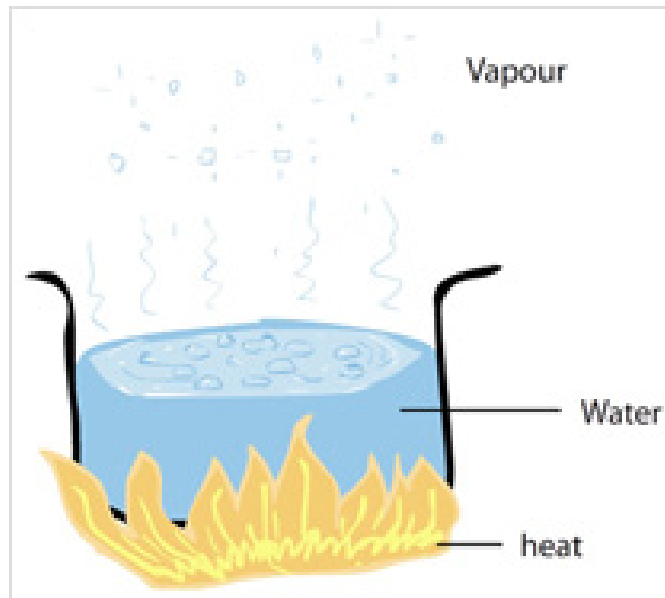
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Philosophy

The design process for explaining a science concept as a Narrative emerges from General Principles in Theory of Knowledge. Within the theory of knowledge three domains are most significant in understanding the Nature of Science. These are:
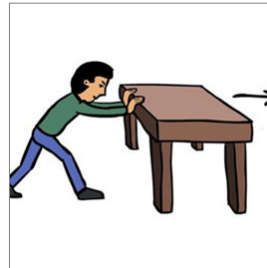
Ontology

Epistemology

Logic

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Ontology

One of the most fundamental questions to be asked about existence is "What exists?"

• For example if one is standing outside a room, one can ask a question, what exists inside the room? The answer can be table, chair, bed etc.

• Similarly one can ask "What a room is made of?" The things that exist in order to make a room are Bricks, Walls, and Cement etc. "What exists" question comes from the need to know what something is made up of.

• Similarly, one can ask "What exists in this Universe." It is the same as saying what the Universe is made up of.

The answer that ontology provides is: Objects, Properties and Events. In modern literature, 'Objects' have been replaced with 'Concepts' and 'Properties' have been replaced with 'Relation'. Hence, what exist in the Universe are Concepts and their Relationships with each other.

To have knowledge about something is to know the relationship that thing has with what it is related to.

Examples:

• **Static Relations:**

1. **The Book is Lying on the Table.**
   - Here there are three terms that are in relation to each other.
   - Book and Table are terms which are joined by the relation 'Lying'.

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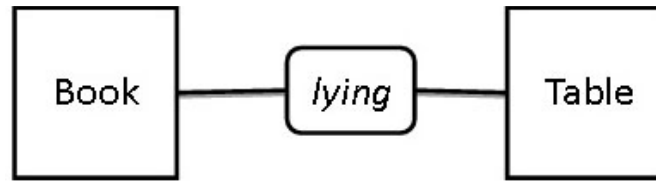
2. Rahim Pushed the Table.
 - Rahim and Table are objects connected by the relation 'Push'.
 - Show image of Rahim pushing a table.
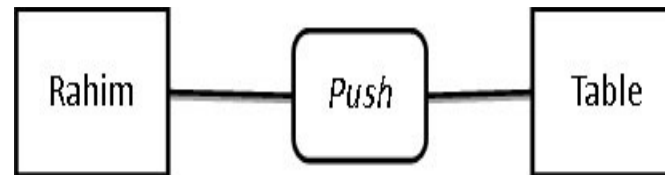
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In the first statement, no action is happening and in the second action is happening. Both are events. The first is simply telling the position of an object with respect to another. And, second sentence tells the effect of one object on another.

3. Blood is Red.
 - Here the object is **Blood** and **Redness** is its property.

Property is not expressed as a relation. It is only an attribute of an object. But here again, there is an underlying relation. Red is one of the categories of color. Red connects Blood with a general category Color.
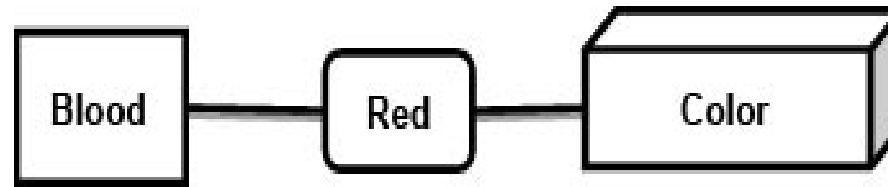
4. Pushpa is Indian.
 - This is similar to Blood is red.

Here Pushpa is connected with the category of Nationality. The connecting property is Indian. Nationality can be many other things like Chinese, American etc.
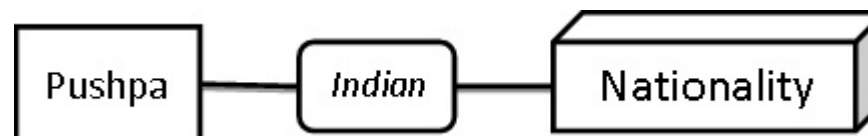
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5. Humans are Intelligent.
 - This is similar to Blood is red.

In this statement two categories are in a relation; Humans and Character, connected by relation intelligence. Quality or character can be many things like kindness, Jealousy, Anger, Courageous etc.

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6. This Bottle is made of Steel.
 - Here again Bottle is connected to one category of materials which is steel.
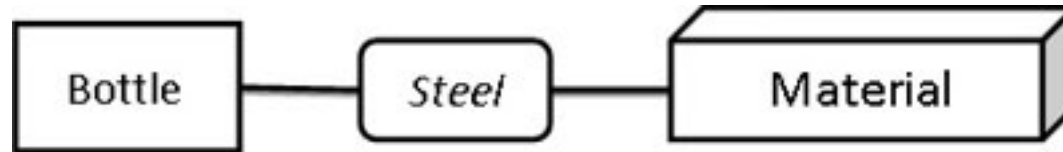
We can extend it and say, Steel is strong. This is similar to saying that Humans are intelligent
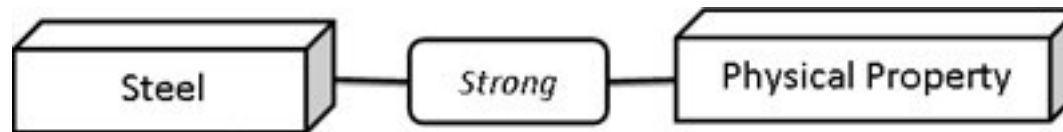
Similarly when it is said that Steel is strong, it is a **General Statement** about the category steel. This can also be expressed as All Steel is strong.

When it is said that Humans are intelligent. It is a **General Statement** about the Category humans. This can also be expressed as All humans are intelligent.

But if one says that this bottle is made of steel, one is only stating a singular fact. It is only applicable to one thing. This is a **particular statement.**

The statements seen so far are about fixed attribute of something. We can call them **Static Relations. • Dynamic Statements:**

Example:
1. When water was heated, it turned into vapor.
 - This is a statement of a single fact.
 - Here Heat is the causal relation between Water and Vapor

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If we say; when heat is applied, all liquids turn to vapor. This is a **general principle** explaining the qualitative law of Vaporization.
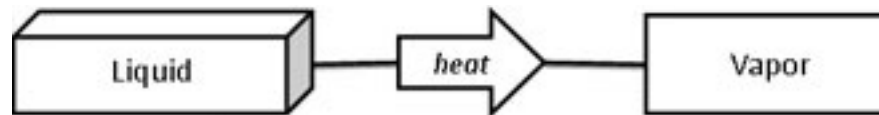
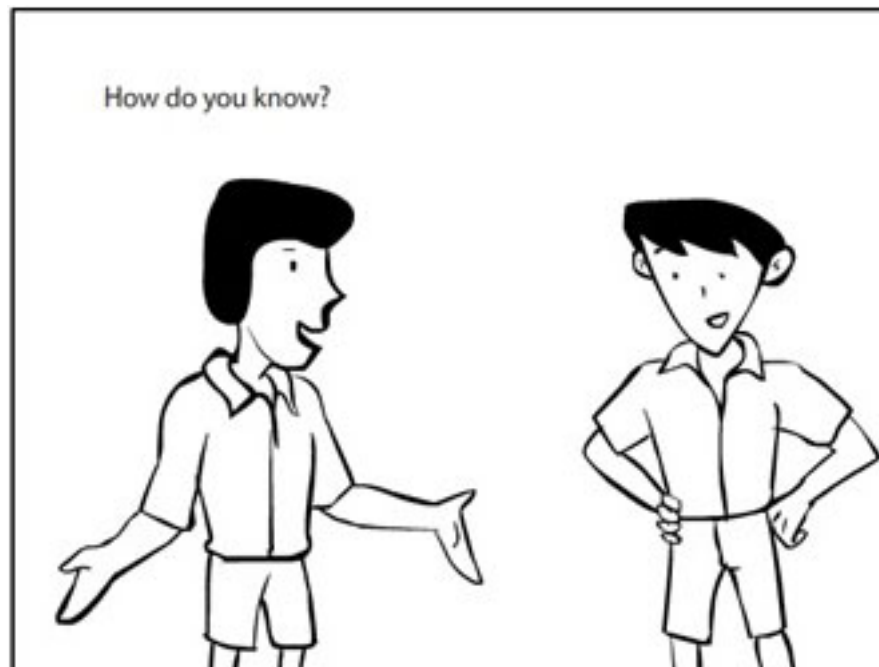Design Resource
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The statement is about some event happening. Hence, we can call it as **Dynamic Relation.**

SUMMARY:

So far we have seen following aspects:

• There are relations in which more than one objects or terms are connected or associated with each other.

• The relations are static or dynamic in nature.

• Static ones classify the relation by giving them fixed properties or attributes. Like Blood is Red or Pushpa is Indian. Or All Humans are Intelligent. While Dynamic relations are associated with events and actions. Like seen in example of water evaporates on being heated or Rahim Pushed the Table.

• The relations are expressed in two ways: In terms of
(1) Facts and (2) General Principles.

• Facts are single events or instances: For Eg. This bottle is made of steel.
General Principles are relations common to a group of objects:
For Eg. All steel is Strong

• Also, Facts can be both - Static and Dynamic. For Eg.
- This bottle is made of steel is Static Fact.
- Rahim pushed the table is a Dynamic Fact

• And, General Principles can be either Static or Dynamic. For Eg.
- Blood is red is a Static General Principle
- When liquids are heated, they Vaporize is a dynamic General Principle.

• Facts and General Principles are themselves related with each other as:
Facts leads to formation of general Principles.

• The end of any scientific investigation is to produce a statement about relationship between certain entities or concepts.

• The process by which the validity of a statement is tested is the subject matter of Epistemology.

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Epistemology

In ontology, we saw that the universe is made up of **concepts** and **relations.** We have also seen that the relations can be expressed as propositions of Facts or General Principles. But a fact can be **true, false** or **partially true.**

Examples:
1. If someone says that 'Sahara Desert is in India.' It is a **False** statement.
2. Or if someone says that 'Water turns into gold on heating', it is a **False** General Principle.

• How does one know that a certain Fact or General Principle really exists or not?
• In other words, what is the reason for believing in something to be the case?
• What is the evidence or proof of a certain Fact or General Principle?

This is the subject matter of **Epistemology,** which looks at proof or evidence for existence of a **Fact or General Principle.**

• **Proof of a fact** can be known by sense observation.
   For Example: Rohit saw a red colored liquid.

- The proof of this can be known by perception of the liquid as red.
- If the liquid is actually red, then the fact is confirmed.

• **Proof of a fact** can also be provided by Deduction.
   For Example: Aseem has come to school today.

This fact can be proved by the following deduction.

P1: Aseem comes to school with a red bag
P2: The red bag is present today
Conclusion: Therefore Aseem is present today.

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• **Proof of a General Principle** is given by Induction and Experimentation.

For Example:
Consider the General Principle : Water is an essential ingredient necessary for plant growth.

To prove this inductively, many plant that receive water need to be observed. If all of them grow well, then the general principle is 'If there is water, Plants grow' is held to be true.

But Induction is not sufficient. It is coupled with Experimentation. In experimentation, conditions are deliberately manipulated and their results are matched with expected outcome.

For Example:
In Experimentation, Some plant samples are collected. They are divided into two groups.
- One group is fed water; the other group is devoid of water.
- The result in Growth is observed in both cases.

If it shows that the Plant fetched with water grew well and those not fetched with water did not, confirms the General Principle that "If there is water, there is Plant growth".

Asking for a justification of a statement always proceeds with a question. Like 'How do we know that water leads to plant growth?'

Proof of a General principle follows a systematic, sequential order. The structure of this order is described in subject matter of Logic.

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Logic

Logic is the step by step sequential method of providing evidence or proof of a proposition, Belief, or theory.

There are two fundamental types of Logical schemes.
• Formal Logic and
• Symbolic Logic.

In this section we will only deal with Formal Logic.

The purpose of studying formal Logic is only to emphasize the sequential arrangement of propositions and how they are linked with each other. Based on this understanding, the structure of Narrative Logic for explaining scientific inquiry process will be explored.
Example: Let us consider a proposition: It is going to rain today.

One can ask for the evidence or proof for believing that it is going to rain today.

The step by step method of proving is as follows:

A General Principle related to rain is to be stated. (Also known as major premise).
Example: Whenever there are dark clouds and there is thunder, there is rain.

WE KNOW BY EXPERIENCE THAT WHENEVER THERE ARE DARK CLOUDS, THERE IS RAIN

A particular fact stating the presence of things linked with rain is stated.
(Also known as minor premise).
Example: Today there are dark clouds and there is thunder.
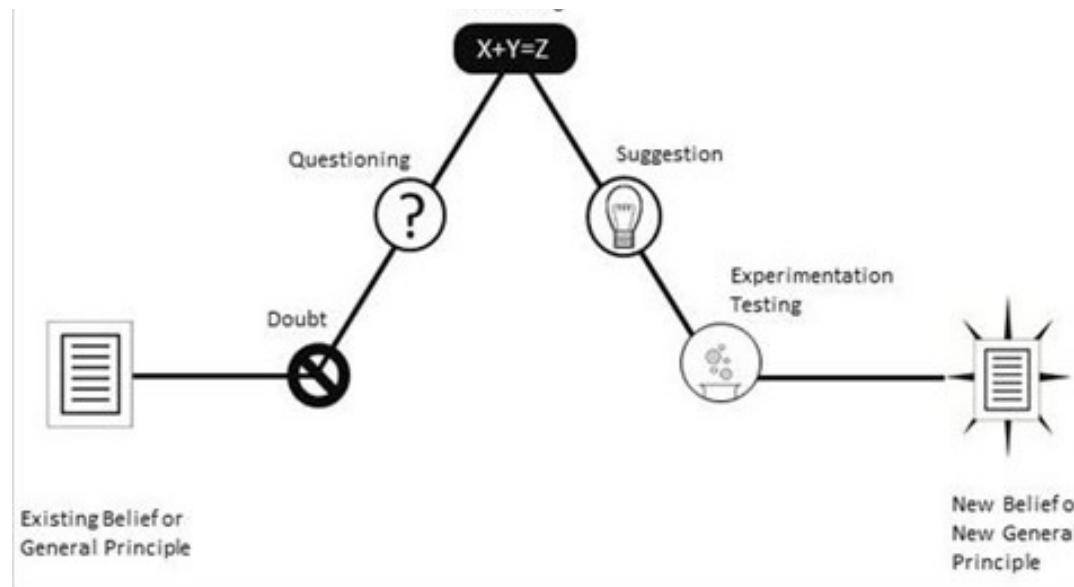
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Then the conclusion of the argument which connects the major and minor premise:
Hence, "It is going to rain today" stands proven.

This is the structure of a deductive argument. It is only useful in providing proof for particular Facts. But general principles are proven through Induction and experimentation. The structure of Inductive argument is different.

Consider a General Principle: All Metals are strong

The inductive proof of this is as follows:

1. List down all things that are strong:
Iron is Strong, Copper, Bronze, Gold, Silver and Cobalt is Strong.

2. Now identify the type of the listed things:
Iron, Copper, Bronze, Gold, Silver and Cobalt are Metals

3. From the Premises, one can conclude that – "All Metals are Strong."
The formal structure of this argument is: If X is A and Y is A, therefore X is Y.

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Example : For Justification of a Dynamic General Principle.
Conclusion: When monsoon is on time, Harvest is Good.

How do we prove that this statement is true?
Premise 1: In 2005, 2006, 2007, 2008, 2009, 2010 Monsoon was on time
Premise 2: In 2005, 2006, 2007, 2008, 2009, 2010 Harvest was good
Conclusion: Hence, it appears that 'whenever Monsoon is on time, Harvest is Good seems to be a general Principle governing good harvest.

There are two basic type of propositions:
• There are Propositions that state a general principle and
• Those that state a fact.
• A third type is one stating a probable general principle.
 - A probable general principle can be termed as a belief.
 - It is a belief because it is not tested or justified yet.

We have seen that proof of the General principle is presented in a sequential manner. The systematic way of presenting proof is elaborated in domain of logic.

In the next section, we will see another sequential way of presenting proof of a General Principle. This is the Epistemic Narrative Structure. Through this method, not just the proof of one concept is represented but also, the evolution of the concept through subsequent proof is presented. This way, one moves from simple to complex concepts and traces their evolution in a series. The Epistemic Narrative Structure provides a logical sequence for arrangement of concepts from simple to complex along with their proofs.

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Epistemological Narrative Structure [ENS]

Just like Logic has an ordered arrangement of sentences or proposition, Narrative structure has an ordered arrangement of 'Event' sentences.

• A general Narrative structure has a following sequence of events:
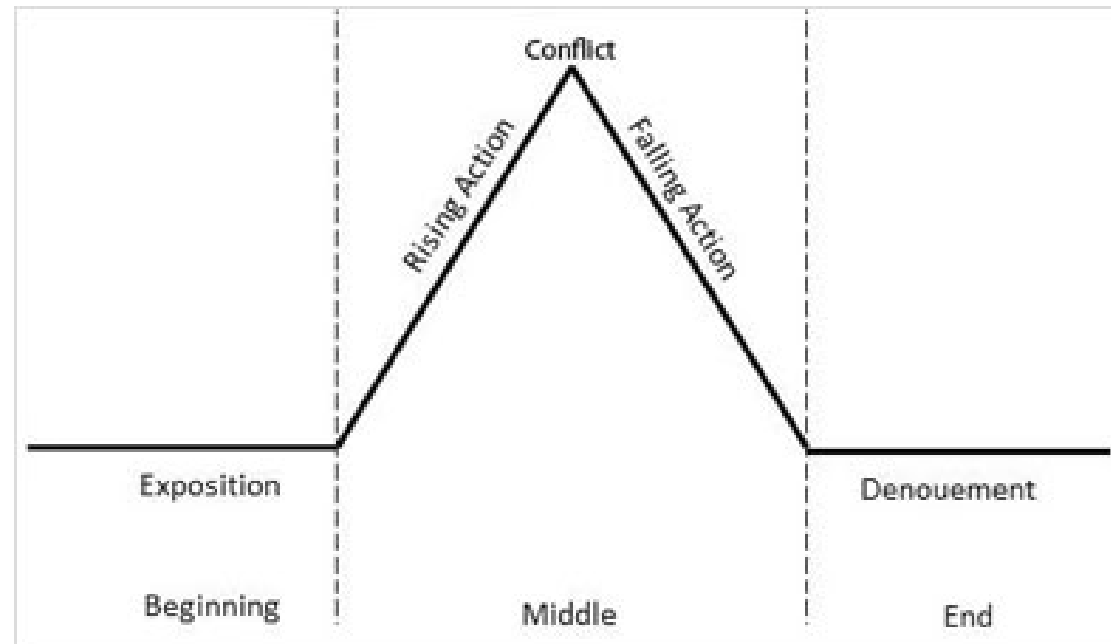
This structure has five general events:
Exposition, Rising action, Conflict, Falling Action and Denouement.

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A variety of general sequence of events comes under this narrative structure.

- **Exposition** elaborates the current state of routine affairs.
- The **Rising Action** details some disturbance in the otherwise peaceful routine affairs.
- The rising action leads to a point of maximum **Conflict**.
- Then event that results in resolution (**Falling Action**) of conflict happens.
- This finally leads to the return of peaceful new state (**Denouement**)

These five narrative events can be mapped onto a scientific inquiry event. In the case of a scientific inquiry, the five events become:

- Exposition   > Existing belief
- Rising Action > Doubt
- Conflict   > Hypothesis [hypothesis conflicts with existing belief]
- Falling Action> Experimentation [if the experiment is successful, but that is not necessary]
- Denouement > Establishment of a new belief or theory
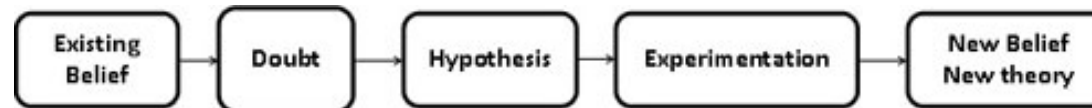
• It can also be graphically represented as:
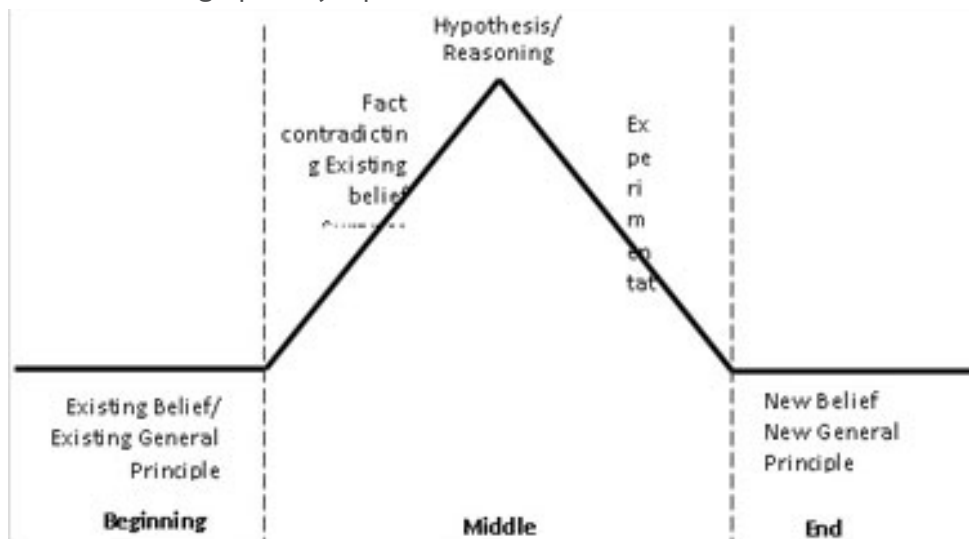
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• It can also be graphically represented as:

• The detailed narrative structure for a scientific inquiry event that leads to formulation and acceptance of a theory is given by:
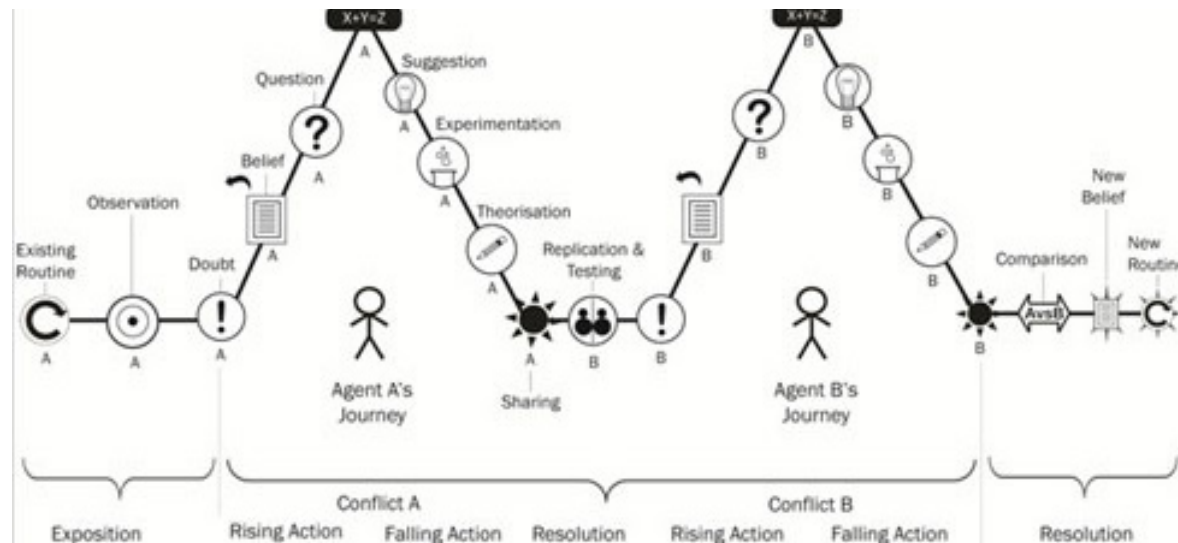
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• Constituents of a scientific discovery event are:
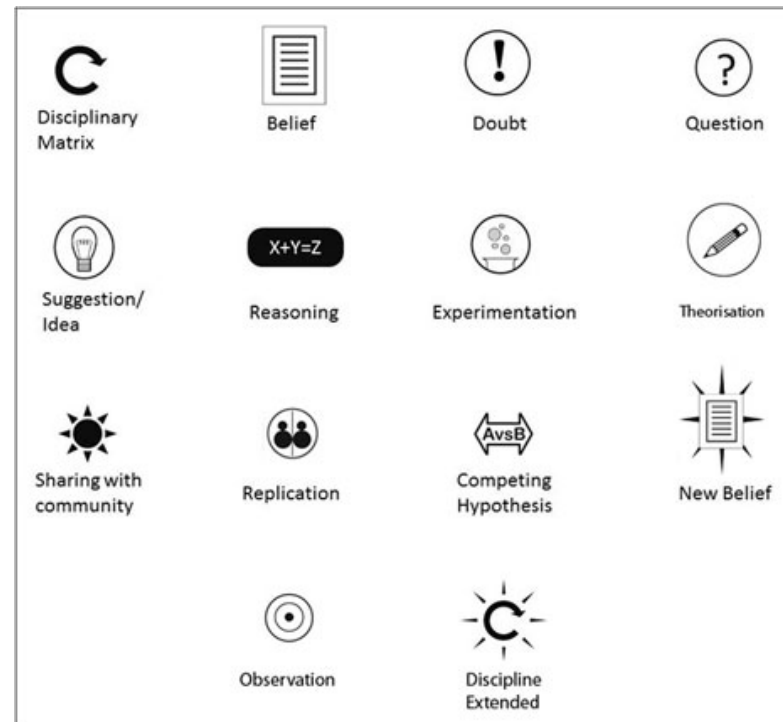
• Description of each constituent element is given as follows:

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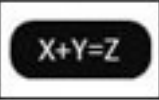
Symbol	Description
	Existing Belief or general principle is a sentence that describes relation between two or more concepts.
	Existing routine is a sentence that describes a particular event that happens as expected according to Existing Belief.
	Doubt is a sentence that describes a thought that occurs when a particular event does not happen according to some general principle.
	Question is a Sentence that asks why particular event did not match general principle.
	Reasoning is a sentence that searches for other similar events in the past and links them with current event.

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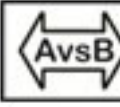
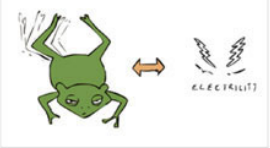**Source:**
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	Hypothesis/Suggestion is a statement that states a proposition regarding a new relation between concepts.
	Experimentation is a sentence that states that one concept in the suggestion was present then the other concept was also found to be present as predicted.
	Theory is a statement that states relation between certain concepts as a general principle or law.
	Sharing with community is a sentence that describes an event or set of events in which the actor shares his/ her proposition of new belief with the community.
	Replication is a sentence that describes an event or set of events in which the experiment done by an actor is repeated by another actor.
	Comparison is a sentence in which the community debates about choosing the proposition to be accepted a s theory which will establish a new justified belief.is a sentence in which the community debates about choosing the proposition to be accepted a s theory which will establish a new justified belief.

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Design Process

Design Process for Creating a Story for Science:

Step 1: Selection of Topic
According to this framework, it is not possible to make a story for a single concept. The concepts to be taught need to be linked with each other in an evolutionary series. For this reason, the main topic to be selected in this framework is evolution of a domain, for example history of electricity, History of clothing etc. All subordinate concepts in history of a domain are joined in a series.

Step 2: Literature Search
Literature on history of a domain is searched. It can be either done through website or textbook available in a reputed library. For authentication of data, the history has to be cross check with multiple sources. If more sources are providing same narration of a discovery event, chances are the data is reliable. From the literature, names of main protagonists are to be extracted.

Step 3: Narrative Structure
Write down the contribution of each actor in the history of the domain. There will be many names present in the history of a domain. Documenting names of each is not important. Note the names of only those who have extended the field by presenting contradictory theory rather than affirming existing one. Most of the science involves in affirming existing theory or belief. But the protagonist who presents alternate explanation or theory to existing theory or belief, only their contribution is to be noted.

Mark those points as significant in development of a field.

Step 4: Building the Narrative
Fill up each event as described in the ENS with the data collected in step 2 and step 3. It is not necessary that all elements will be present in exactly the same sequence as described in ENS.

Write the contribution of each actor under the following headings:
Routine Activity, Observed Fact, Question, Reasoning, Answer, Experimentation, Theory.

Example from History of Electricity: The Story of a Voltaic Cell

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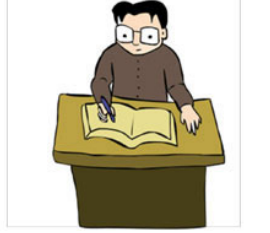
Story Example

Visual Story Example for Epistemological Narrative Sentence Sequence.

Voltaic Cell : The Complete Story

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Source:
http://www.dsource.in/resource/narrative-science-education/story-example

Design Resource
Narrative In Science Education
Story Construction for Science Education
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http://www.dsource.in/resource/narrative-sci-ence-education/exercises

Exercises

Taking the reference from "The story of a Voltaic Cell" below exercises can be solved:

1. Complete the story of electricity from Greek to Industrial Revolution.

2. Write the story of Astronomy, Heat, Mechanics, Optics, Hydraulics, Pneumatics and chemistry.

3. Write the contribution of Lavoisier in development of modern science. Write his contribution in the following sequence:
• Routine Activity,
• Observed Fact,
• Question,
• Reasoning,
• Answer,
• Experimentation and
• Theory

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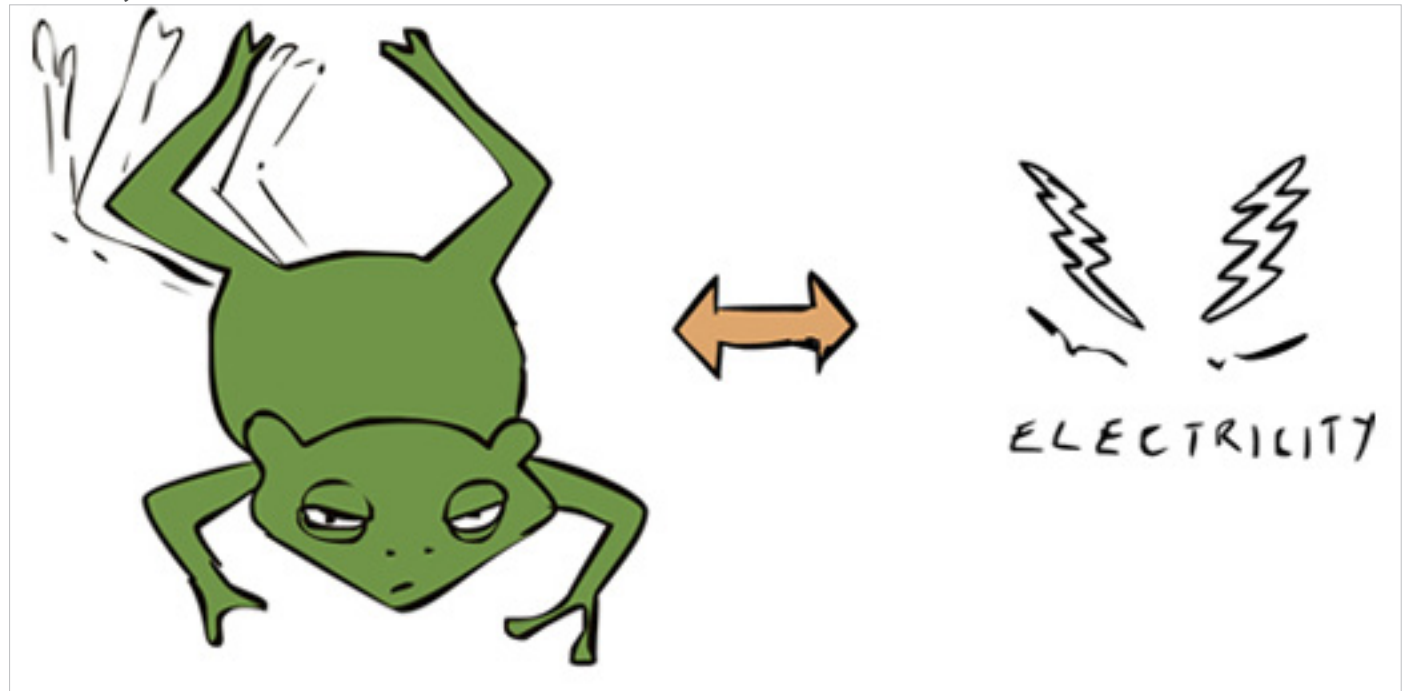http://www.dsource.in/resource/narrative-sci-ence-education/contact-details

Contact Details

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You could write to the following address regarding sugestions and clarifications:

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