Learning through Gaps

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What is Learning Through Gaps?

- Creating learning opportunities for students to make cognitive moves
- Leaving “gaps” in subject delivery for the students to fill in at the cognitive level
- Cultivating curiosity in your subject by presenting it as an intellectual puzzle

About me

- 20 years experience as a high school teacher of science
- 12 years as a coordinator / department leader of science
- Currently Head of Science at the Franconian International School in Erlangen (IGCSE, IB Diploma)
- Formerly Director of Teaching and Learning at St. Leo’s Catholic College in Sydney, Australia

Session overview

- Theoretical background
- A gap “practical investigation” lesson
- A gap “theory/research” project
- A gap “discovery/inquiry” unit


THE ZONE
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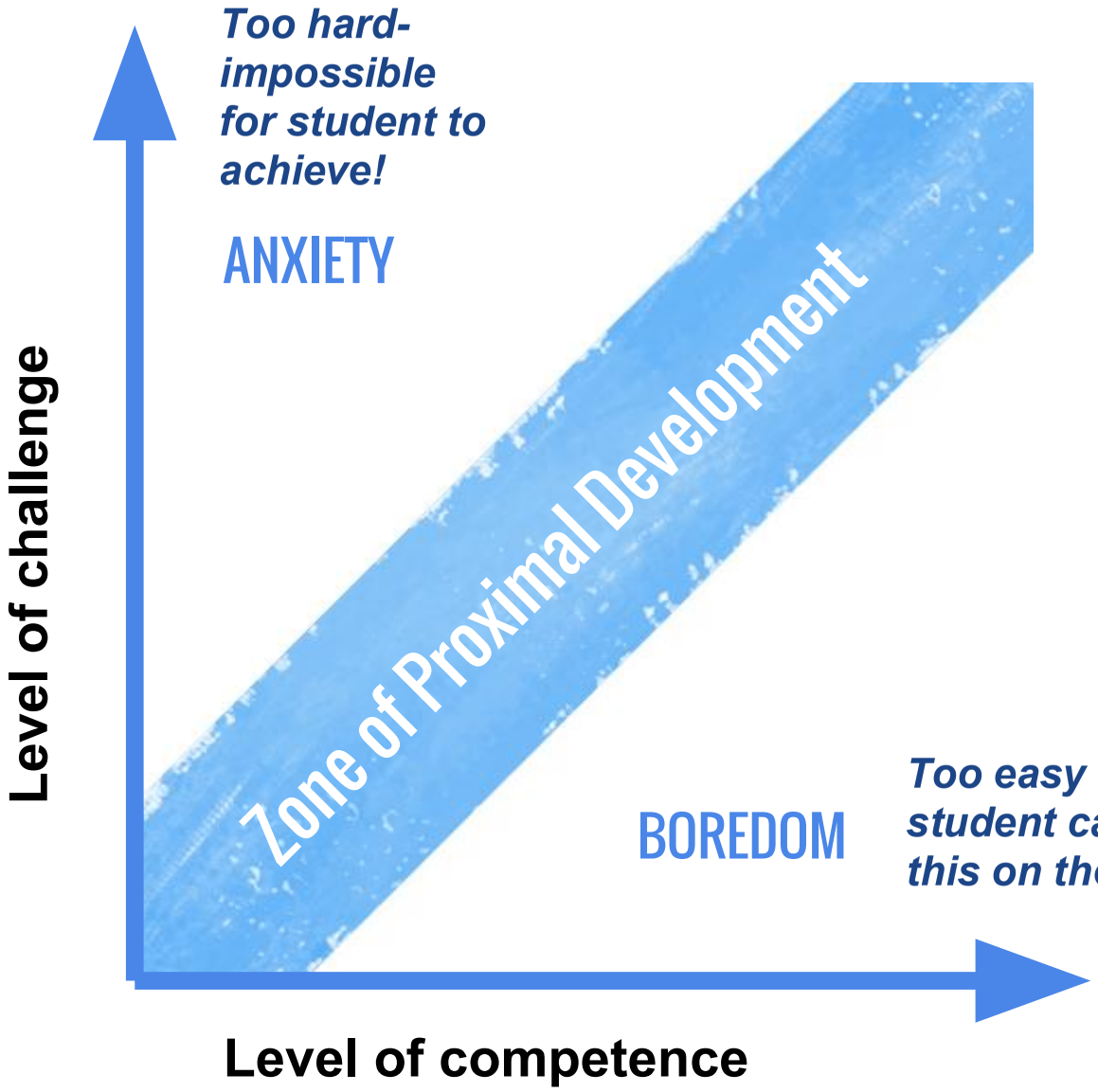
Vygotsky's Zone of Proximal Development (ZPD)

"The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers."

Vygotsky (1978)



Adapted from Victoria State Government Education and Training (2014)

Gap Teaching and the ZPD

- Gap Teaching targets the student's conceptual understanding based on the development of cognitive abilities
- Students raise to the next developmental stage by filling the "Gap"
- Gaps must be challenging but achievable
- Students learn by working with and observing their peers

Operational Thinking and Cognitive development

Formal operational thinking is characterized by the ability to hold a number of variables in mind at once—for example:

- to be able to weigh up two sides of an argument,
- to consider even-handedly the advantages and disadvantages of a particular course of action,
- to be able to see both the separate and combined effects of a number of input variables (for example, sunlight, carbon dioxide, water) on an outcome (the production of glucose).

What Research says about Learning and Increase in intelligence

- *People with faster processing speed show higher implicit learning scores and improve academic achievement* (Kaufman et al, 2010)
- *Promoting and supporting learning is a route to improve intelligence* (Ceci, 1991)
- *Fluid ability is highly correlated with working memory capacity.Fluid ability is now a firmly established construct in education, psychology, and the social sciences more generally. It is likely to continue to draw research attention into the foreseeable future just as it has over the past 50 years.* (Kyllonen & Harrison, 2017)

CHC (Cattell-Horn-Caroll) Theory *(It combines the Fluid and Crystallised theory with the Three-Stratum theory)*

- **Fluid intelligence** is the ability to solve problems in unfamiliar domains using general reasoning methods. It reaches peak around adolescence and it improves if the working memory is trained
- **Crystallised intelligence** Is the ability to solve problems or answer questions in familiar domains using knowledge and strategies acquired through education, training or acculturation. (depends on fluid intelligence and it increases with age)
- The **Three-Stratum theory** superseeds the Fluid-Crystallised theory and it identifies three levels of cognition: Narrow abilities, Broad abilities and General abilities

[From McGrew 2004]

Broad abilities (we, the teachers can influence them)

- Comprehension Knowledge
- Reading and Writing
- Quantitative knowledge
- Fluid reasoning
- Auditory and visual processing
- Processing speed
- Short term memory
- Long term storage and retrieval

Narrow abilities (I) - Fluid reasoning

Inductive reasoning - the ability to reason and draw conclusions from given general conditions or premises to the specific.

Deductive reasoning - Reasoning from specific cases or observations to general rules or broad generalizations

Piagetian reasoning - seriation (organizing material into an orderly series that facilitates understanding of relationships between events), conservation (awareness that physical quantities do not change in amount when altered in appearance), classification.

Speed of reasoning - Speed or fluency in performing reasoning tasks (e.g., quickness in generating as many possible rules, solutions, etc., to a problem) in a limited time

Working within the ZPD

What skills and knowledge do my students need to reach this outcome/complete this task?

- How can I lead them to construct this knowledge?
- How can I challenge them appropriately to develop these skills?

Scaffolding - lesson / task / unit design
One-on-one support - checking for understanding and asking good questions
Collaborating on a complex task or problem with peers - giving students time to puzzle and work things out on their own or with their peers

Year 5-6 writing an essay for the first time

Prior knowledge and competence: Paragraphs

Too easy

A ready made introduction, and all topic sentences, students complete the paragraphs

Should we read more books from other c languages?

It is often said that books are our windows t and times. Everyone agrees that reading bo but how often do we get to read books from If books are windows, then all our windows f direction – how big is the world we get to ex well as English literature we should also be from other countries, cultures and language up our world, improve our general knowledg understand each other.

Reading books from other countries will broa perspective of the world.. …..…….

……

……

……

Imagine how much richer our general knowl we regularly read books even from three diff

……..……

……

Too hard

An essay topic only

Should we read more books from other c languages?

Just right

An essay outline and some suggestions.

Should we read more books from other countries and languages?

Introduction: hook the reader, give an overview of the issue, outline your points.

E.g. It is often said that books are our windows to other worlds and times, if this is true then all our windows face in one direction

Why should we read books from other countries?

Generate ideas, sift, sort and sequence ideas

Key idea 1 e.g. *Reading books from other countries will broaden our perspective of the world.*

Evidence/example:

Key idea 2 ……

Evidence/example:

Key idea 3.……

Evidence/example:

Year 8-9 conducting an experiment

Prior knowledge and competence: theoretical background, scientific method

Too easy

All instructions for the practical experiment are scaffolded

Conduct the following to test a theory

Aim, Hypothesis, List of
- all provided.

Procedure - step by step instructions

Blank results table to fill in

Clear guidelines for report

Too hard

Students asked to design entire experiment

Design an experiment to test a given theory

Just right

An essay outline and some suggestions.

Design an investigation based on

Aim

List of materials

Students to develop hypothesis and plan and conduct investigation with some trial-and-error type problem solving

The role of the teacher in Gap Teaching

- To be aware at all times of the **students' level of understanding** of the problem at hand
- Give students **individual guidance on an as-needs basis**
- **Allow the students to make mistakes**
- Rather than pointing out the errors, **ask critical questions** to prompt students to think about and evaluate their processes (e.g. will the analysis be reliable if you only use two secondary sources? have you tested for a range of temperatures? how might your interpretation differ if you consider the ending? What will you do if this doesn't work?)
- **Provide sufficient time** for students to fill the gaps/solve problems/complete complex tasks on their own or collaboratively

Discussion (pairs/groups of 3)

- *Can you remember a time when you gave a task to students which was too easy, too hard, just right? How did you know / feel that it was so?*

The Role of the Teacher:

- *Is this what you are doing in most or some lessons?*
- *Anything that you'd like to add?*
- *Does this approach to teaching and learning fit with your beliefs and practices?*


EXAMPLE 1
A practical investigation lesson

First-hand investigation (e.g. Electrolysis, Fermentation, etc)

1. With only the Aim and materials given (and some prior knowledge), students write a hypothesis and a method. The teacher checks and...ONLY…..suggests where problems might occur

2. Students finalise method and attempt experiment. Students identify what doesn't work. Teacher asks them questions related to the theory in order to bring them back towards the aim and reminds them of the materials available.

3. Students re-design and re-attempt the experiment if necessary. If it still doesn't work, they are allowed to "visit" other groups for inspiration (NOT ALLOWED to ask questions, just OBSERVE)

4. Students write a brief evaluation of the problems they encountered AND what have they learnt about the planning and execution strategies, followed by report.

The Gaps

1. Aim and materials provided but **no hypothesis or method**. The students must write the hypothesis and method. This gap enables students to use their deductive reasoning to work towards a solution based on an existing set of conditions. **(RG - Deductive Reasoning)**

2. Students to identify which of the available materials are of use and which are not. They also may alter their initial set up if necessary (eg: they may only use blue-tak and wrapping paper and leave the sticky tape out when the seal the holes that the carbon rods make through the paper cup). This gap will enable them to identify the materials needed based on the purpose and to set them up in order to solve the problem at hand **(FC - Flexibility of Closure - Recognition of, yet the ability to ignore, distracting background stimuli)**

First-hand investigation (e.g. Electrolysis)

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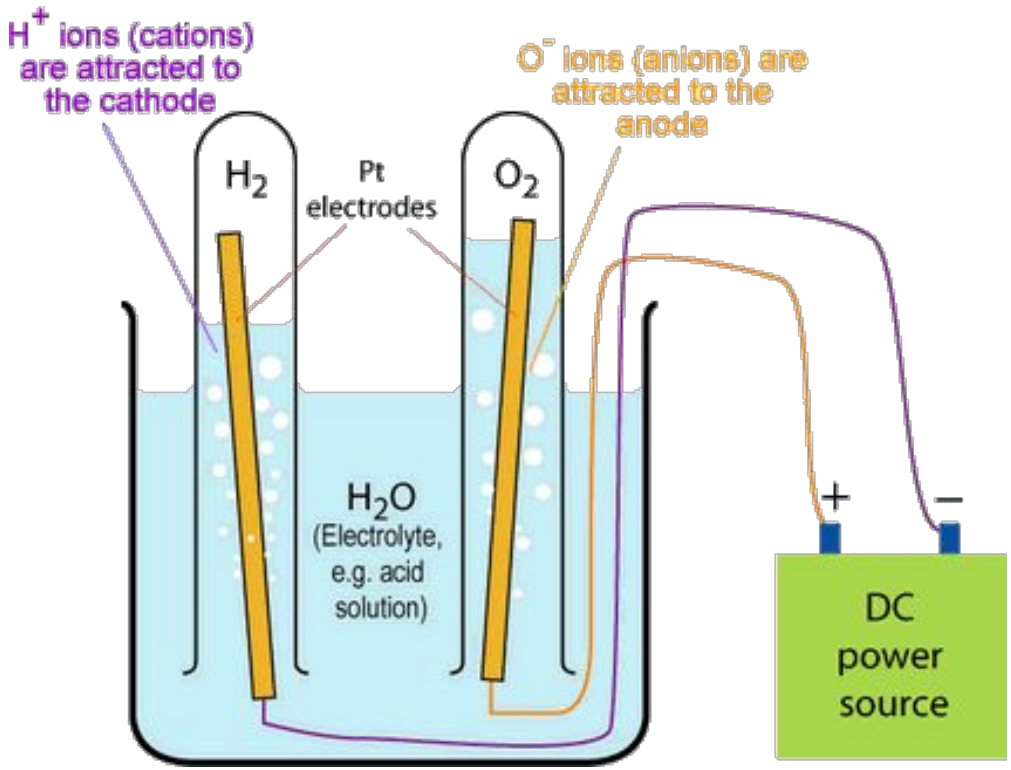
First-hand investigation (e.g. Electrolysis)

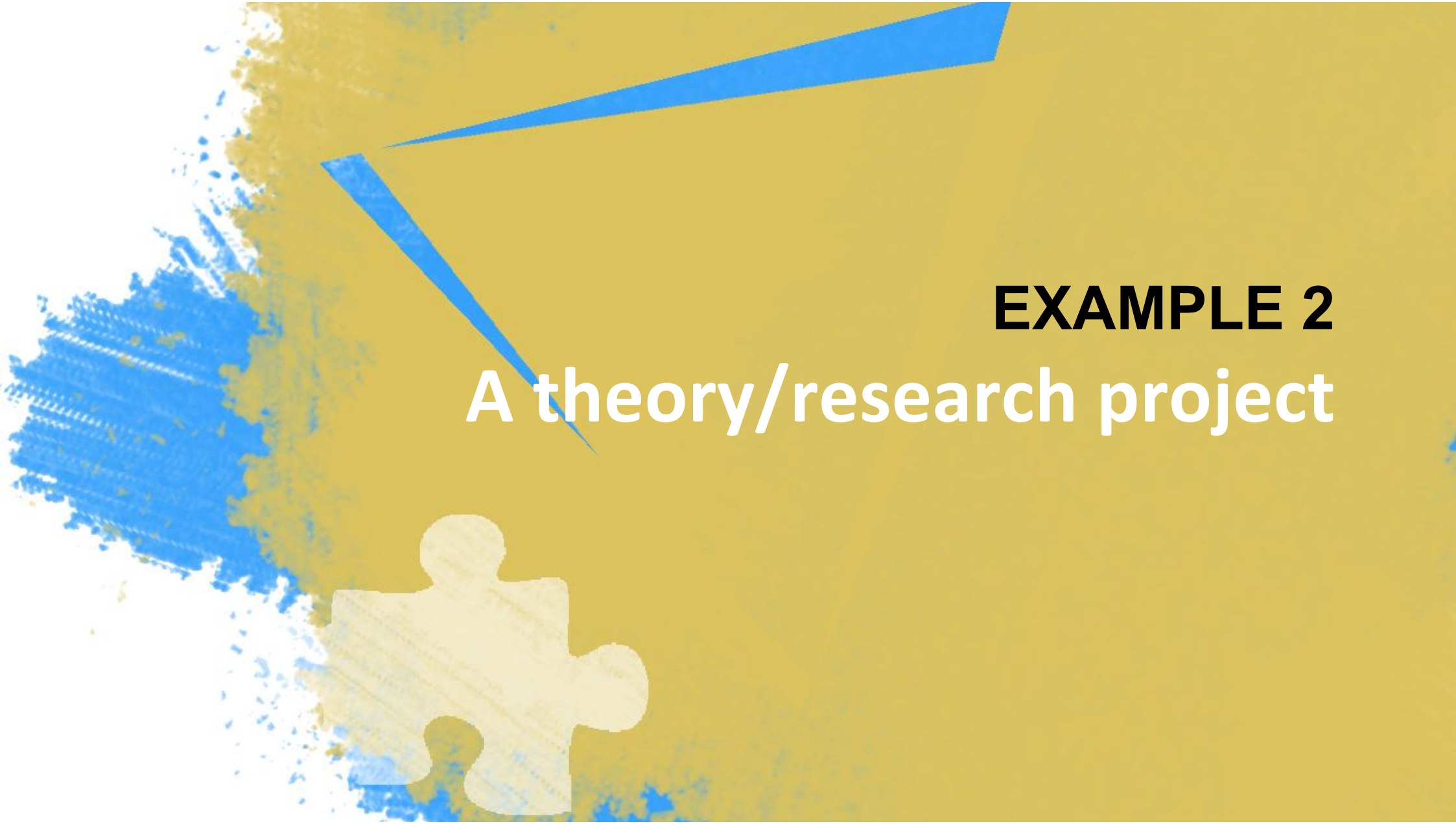
1. With only the Aim and materials given (and some prior knowledge), students write a hypothesis and a method. The teacher checks and...ONLY…..suggests where problems might occur **(RP-Seriation)**
2. Students finalise method and attempt experiment **(RG)** Students identify what doesn't work. Teacher asks them questions related to the theory in order to bring them back towards the aim and reminds them of the materials available.**(CF)**
3. Students re-design and re-attempt the experiment if necessary. If it still doesn't work, they are allowed to "visit" other groups for inspiration (NOT ALLOWED to ask questions, just OBSERVE) **(FX) (SP)**
4. Students write a brief evaluation of the problems they encountered AND what have they learnt about the planning and execution strategies, followed by report. **(FO)**

Electrolysis equipment set-up



Designing activities / lessons with gaps

- Don’t point out connections - **allow the students to discover them**
- Give students a problem or a **complex task** to solve, which requires them to build on the **target skills**
- Let the students investigate the problem and initially **do not answer their questions**, instead directing them with clues so that they may try **work out the answers on their own**
- Ask students to identify and **reflect on the method / processes** they used to arrive at their ideas/solutions/conclusions


EXAMPLE 2
A theory/research project

Theory/Research (e.g. Digestive system)

1. Introduction to digestive system based on previous knowledge including enzyme activity. (10 minutes, teacher-led)

2. Part 1 A: After 10-15 minutes of individual research, in pairs prepare a PPT presentation of a certain part of the digestion system (eg: mouth, oesophagus, small intestine, stomach) .

   Part 1 B: Join with another pair which researched the other half of the system. Show and teach each other how the parts function based on their respective structures. Two of the larger groups will present their Digestive System PPT to the class. Class discussion (1-2 students to compile all information for the whole class by putting the PPT's together).

Theory/Research (e.g. Digestive system)

3. Part 2: (individual) ”*Describe the passage of a morning sandwich through your digestive system, explaining what happens to all the food ingested. Write it as a story*” (it should be “doable in 1 lesson in class plus 1-2 hours at home)

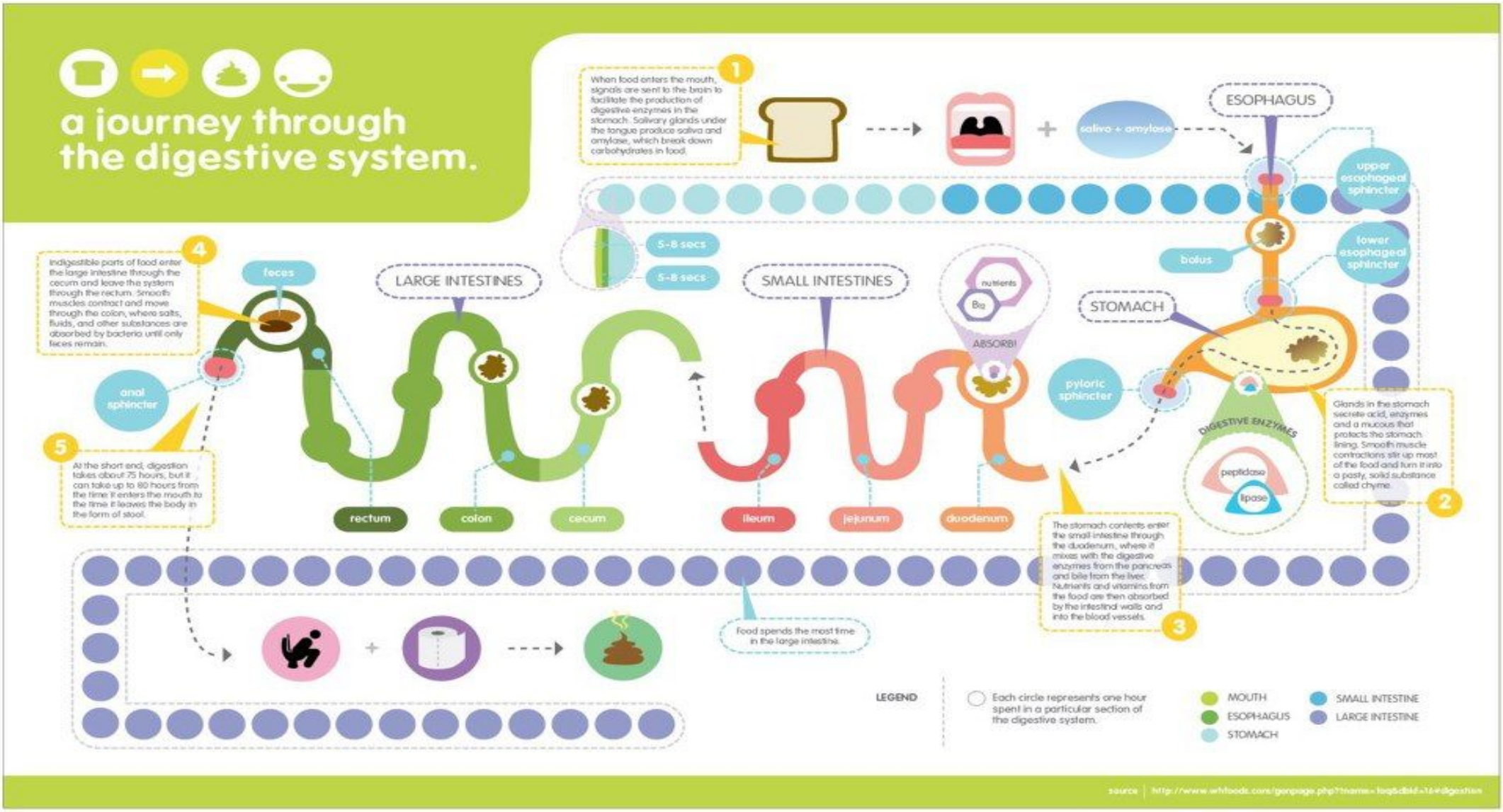
4. Part 3: Now imagine if you had to write this story as an essay…. Construct a Thesis Statement for this essay. (Capturing the key concepts of the process of digestion)

The Gaps

1. Part 1: Working individually, then in pairs, then in groups of four (about 10 min for each) students complete and share the mini-research, discuss important points, clarify knowledge and understanding. Use different colours or fonts for each stage. The gap enables students to decide in a short period of time, which information is important, how and who would present which section and in which logical order (e.g. Oesophagus before stomach and small intestine, use of enzyme before assimilation, etc) **(RE)(MW)**

2. Part 2: Students have all the “ingredients”, the knowledge about each part (first-hand for the half they researched and from listening plus resources for the other half). They need to put the everything together using a narrative. The gap enables the students to communicate information and ideas in written form so that others can understand (with clarity of thought, organization, and good sentence structure). **(FE) (WA) (RG)**

a journey through the digestive system.



source | http://www.whfoods.com/genpage.php?tname=foodbd&dbid=16#digestion

Sample student assignment

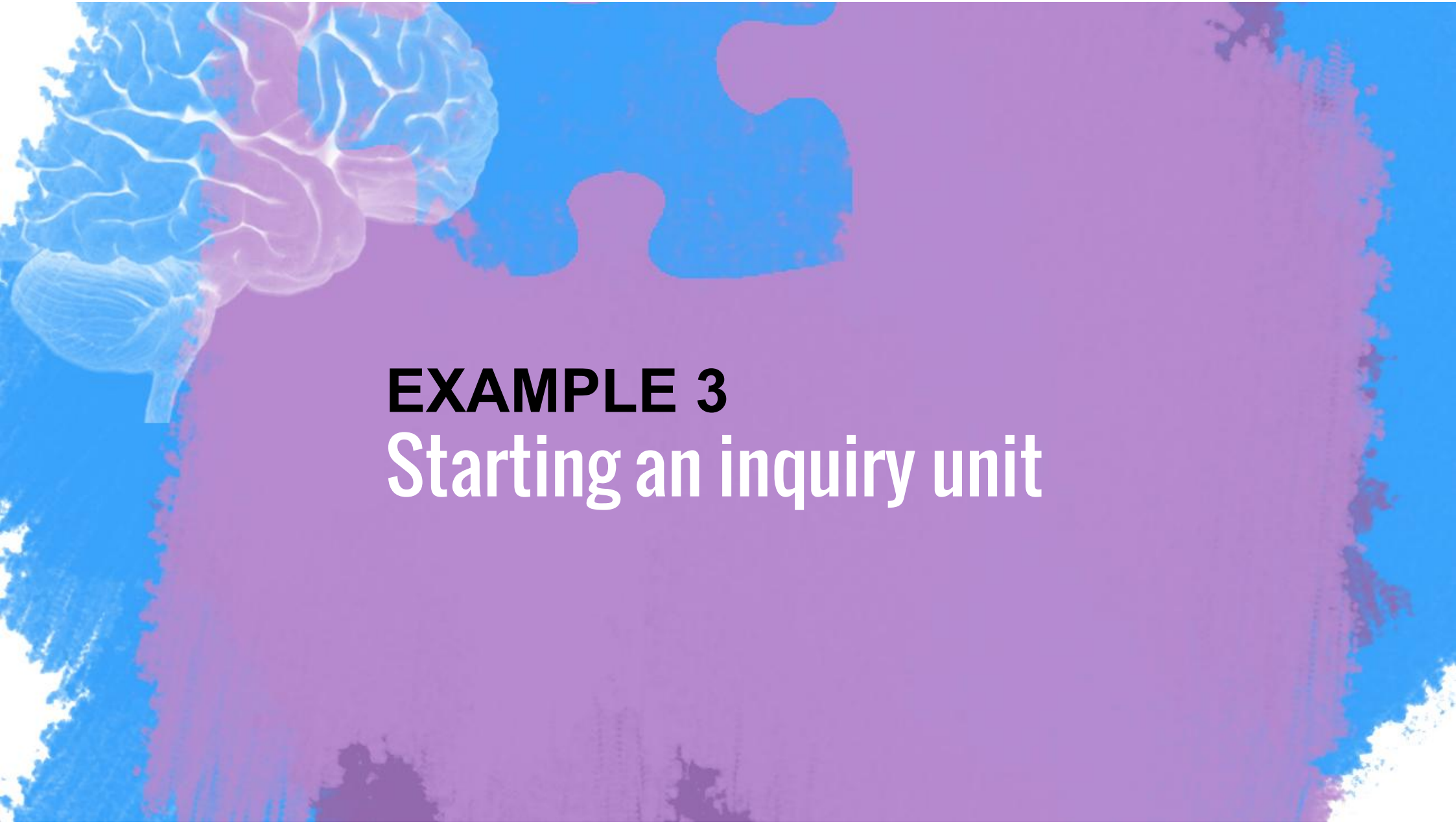
The Great Journey of Sammy the Sandwich

Sarah is a human being, and like every human being, she needs food to live. Her favorite meal of the day is breakfast, and Sarah always eats a “Sammy sandwich” for breakfast. Sammy the sandwich is a very nutritive healthy sandwich made of delicious nutritious whole grain bread, scrambled eggs, cheddar cheese, butter, lettuce. This story is about the journey of Sammy through Sarah, this is what happens after Sarah takes a big bite.

First stop, the mouth. Sammy is torn and ripped by the incisors and canines in Sarah's mouth, this increases his surface area, meaning Sammy gets bigger.. Salivary glands at the back of the mouth produce saliva containing the twin enzymes, Amy and Lase. The increased surface area of Sammy allows Amy and Lase to break down the carbohydrates in the whole wheat bread of Sammy, they turn the carbohydrates into sugars…..

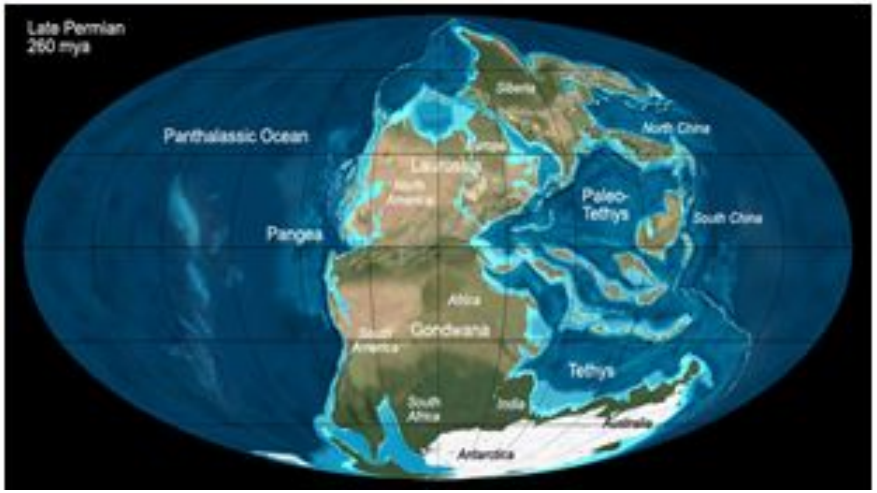
Designing research projects with gaps

- Always **start and finish with students working individually** so they internalise the knowledge and take responsibility
- Have students **teach each other some component of knowledge** after the initial individual research part.
- Essential part of the task should **have students making connections between concepts or facts**. The reason for making those connections to be shared with and questioned by other student(s) in the group/pair and as a further step by a different group/pair
- Students should **demonstrate their understanding in a new form** that requires them to be ‘experts’ in this knowledge



EXAMPLE 3
Starting an inquiry unit

Geology


Late Permian
260 mya
Panthalassic Ocean
Pangea
Laurasia
Siberia
North China
Paleo-
Tethys
South China
Africa
Gondwana
South
America
Tethys
South
Africa
India
Antarctica

Stimulus - introducing the unit

1. Look at the pictures on the slide and write 10 words that come to your mind about them (3 min, individually)
2. Write ten more words that connect two or more of these pictures (3 min, individually)
3. In groups of 3 share the two lists. Each person speak for 1-2 min while the other two listen.
4. As a group come up with two things that you'd like to share with the class

Geology as a wondering branch of science

- Look at the five pictures again
- List 3-5 common things to all of them (GAP-students connect natural features and concepts)
- Write two questions that would help to learn more about Geology

Sample of Students' Questions

Will we study the different types of rocks and minerals?

How are crystals formed?

What makes tectonic plates move?

How do natural disasters start?

Why are diamonds so strong?

How do tectonic changes occur?

How do fossils from and why do they not erode away?

Why do tectonic plates move?

How are earthquakes related to chemistry?

Why do natural disasters occur?

In geology do reactions occur and what are the most common?

Is geology related to animals and plants?

How come fossils from the oceans are to be found here i Germany?

How long does it take to form crystals?

Can fossils be used to create species?

Are there any signs to show us a change of land?

How do rocks and minerals get their colors?

Does erosion happen all over the earth?

Why is there different geography around the world?

Why does everything change over time?

How do we effectively prevent/reduce natural disasters from occurring?

Is there any purpose for natural disasters occurring?

What is the main cause of change?

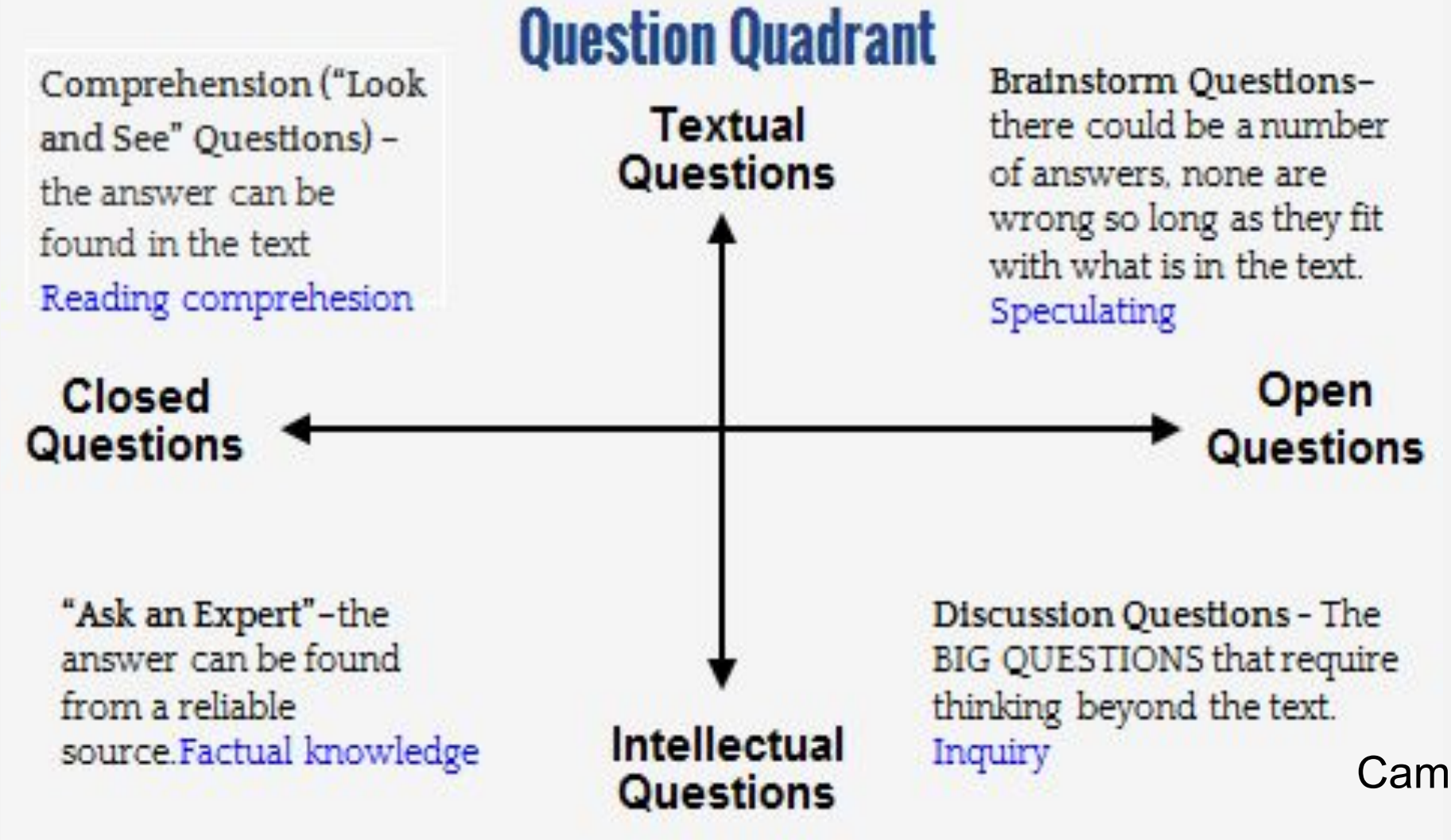
Why do some changes take much longer than others?

Students asked to group the questions

- Closed Questions with a simple answer
- Closed Questions with a complex explanation
- Open Questions with multiple possibilities
- Open Questions with one complex answer arrived at through an inquiry process that looks at alternative answers and applies criteria to identify the best answer

Piagetian reasoning (RP) - seriation, classification.

An excellent tool for a written stimulus or any text



Cam (2006)

Student-Generated Open Ended Questions

Is there any purpose for natural disasters occurring?

What is the main cause of change?

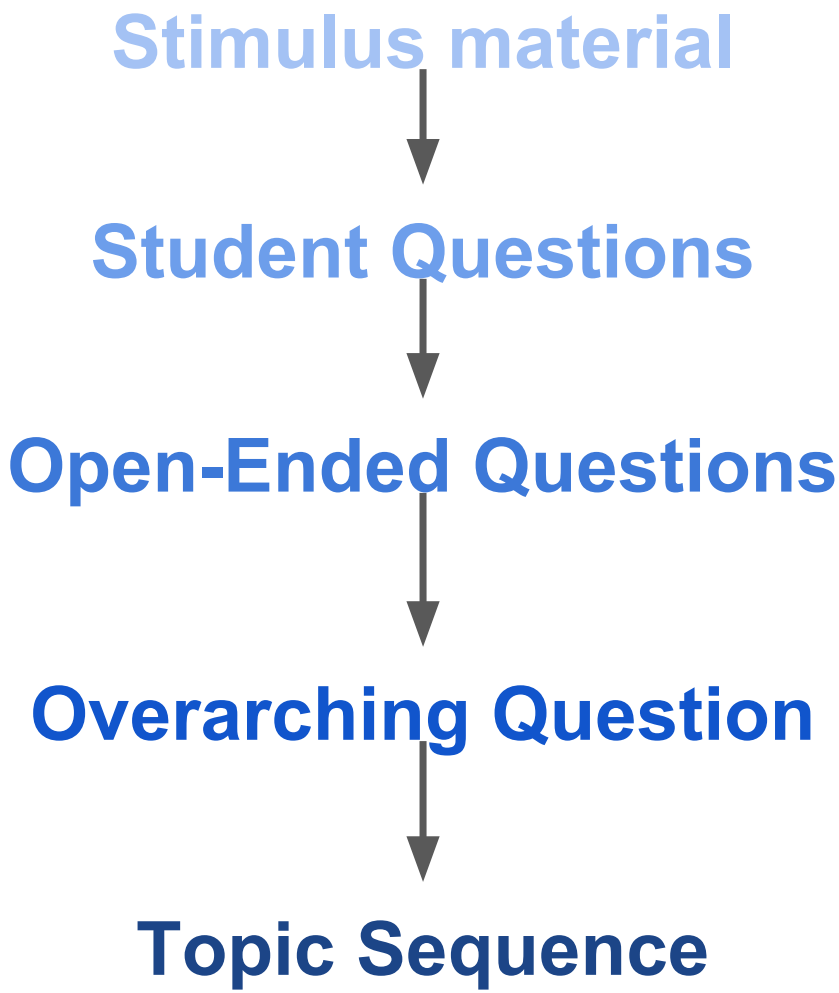
Why do some changes take much longer than others?

1. **Individually students come up with an overarching open inquiry question about this topic. (RG,FO)**
2. **Together with the teacher, the class generates an over-arching question large enough to answer all the students' individual questions**

Why does the Earth change over geological time while the noticeable changes happen for short periods only?

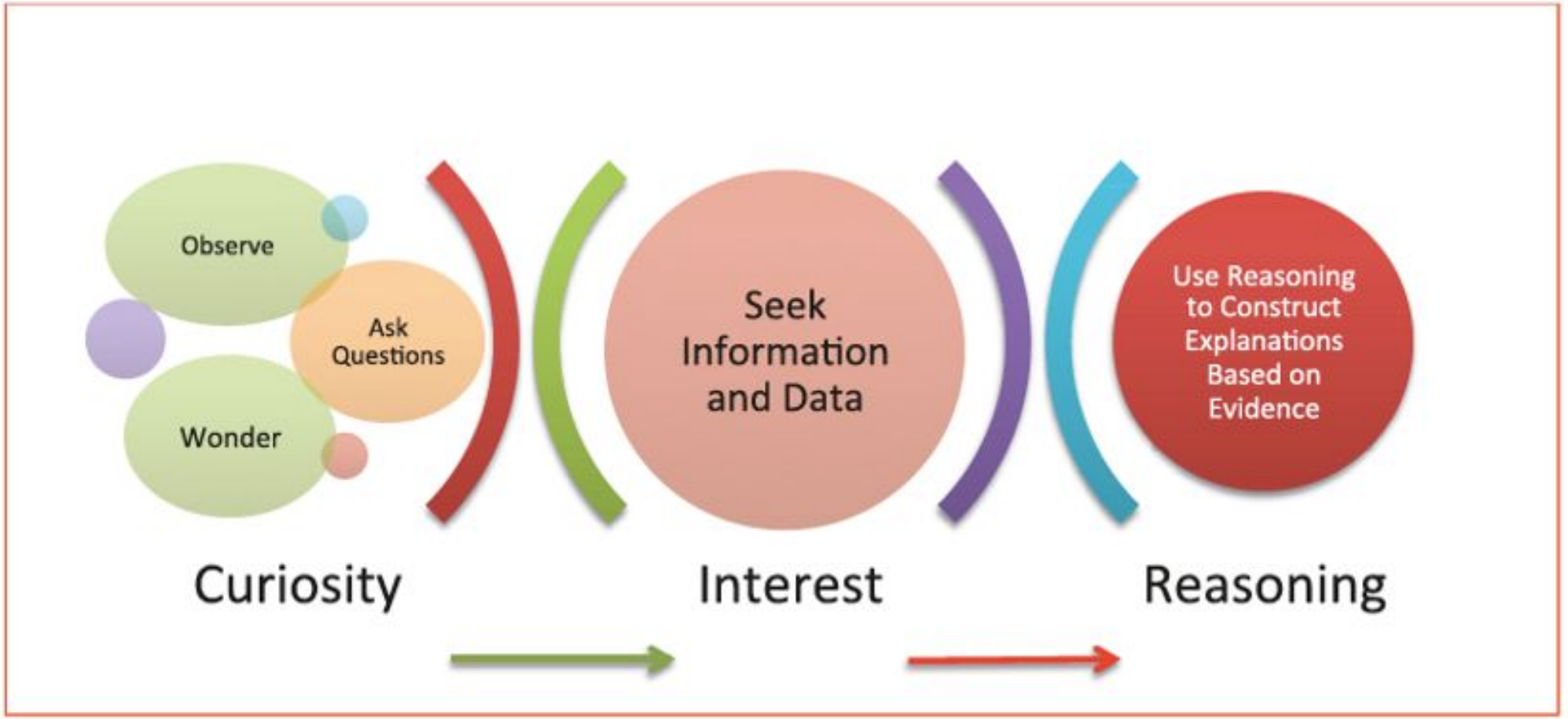
Topic Sequence

CHANGE	1. Changing Earth - Observations, Continental Drift 2. Changing Earth - Mechanisms, Evidence, Theory of Plate Tectonics
TIME	3. Past and Present Features (macro scale) - Landforms, Volcanoes, Earthquakes, Natural Disasters 4. Past and Present Features (micro scale) - Crystals, Minerals, Rocks
LIFE	5. Past and Present: Fossils


Stimulus material
Student Questions
Open-Ended Questions
Overarching Question
Topic Sequence

INQUIRY Unit development

1. Stimulus material to raise curiosity
2. Use a Visible Thinking Routine to make initial connections (e.g. See, Think, Wonder). Additional materials can be provided (e.g. 20 pictures of geological features)
3. Insist on discovering commonalities **(Gap)**. Make a list of them
4. Students to formulate 2-3 questions derived from commonalities that need further exploration **(Inductive reasoning)**
5. Group the questions in four groups.
6. Students comment, observe, realise that by answering the Open Ended Questions, the closed questions will be answered as well but not vice-versa **(Gap)**
7. Using the Open Ended questions students design their own Overarching Question for the topic
8. They “de-chunk” the Overarching Question into 3-4 parts which will represent the backbone of the topic sequence. **(Deductive reasoning)**


Observe
Ask Questions
Wonder
Seek Information and Data
Use Reasoning to Construct Explanations Based on Evidence
Curiosity
Interest
Reasoning

An example student assignment

Task: **Using the map provided or other of your choice in consultation with the teacher, construct an animation which:**

Shows the movement of at least 6 plates (direction is already indicated on the map provided

Indicates one example of mountain building , one of subduction and one of divergent plates

- **You will need to add your voice explaining what is happening**
- **Add drawings and/or diagrams of your own to fully explain the plate movement and the landform formation**

https://drive.google.com/file/d/0BzKoUCQ_gSAWV0RqdGVWSlpvLU0/view?usp=sharing

Designing inquiry units with gaps

- **Start the unit with a stimulus to raise curiosity**. Use a visible thinking routine or similar to encourage students to **think about the stimulus and perform a specific cognitive task**, such as looking for connections *(Generating topic)*
- Teach students the value and skill of questioning by **allowing them to ask questions, categorise and improve the questions** *(Understanding goals)*
- **Use students' overarching question as a basis for the design and sequence of your unit.** Continuously return to the overarching question throughout the unit.
- Have students building up understanding over time and demonstrating it through a **creative assessment task** *(Performance of understanding)* Give them the freedom to choose the presentation format. Progress checked and monitored.*(Ongoing feedback)*

Discussion / reflection

- In groups discuss: **Can you see opportunities for integrating the Gap methodology into your teaching / assessment / planning in NEW ways?**

- Report back: **Any general comments?**

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