Meeting the Challenges of Implementing IBSE

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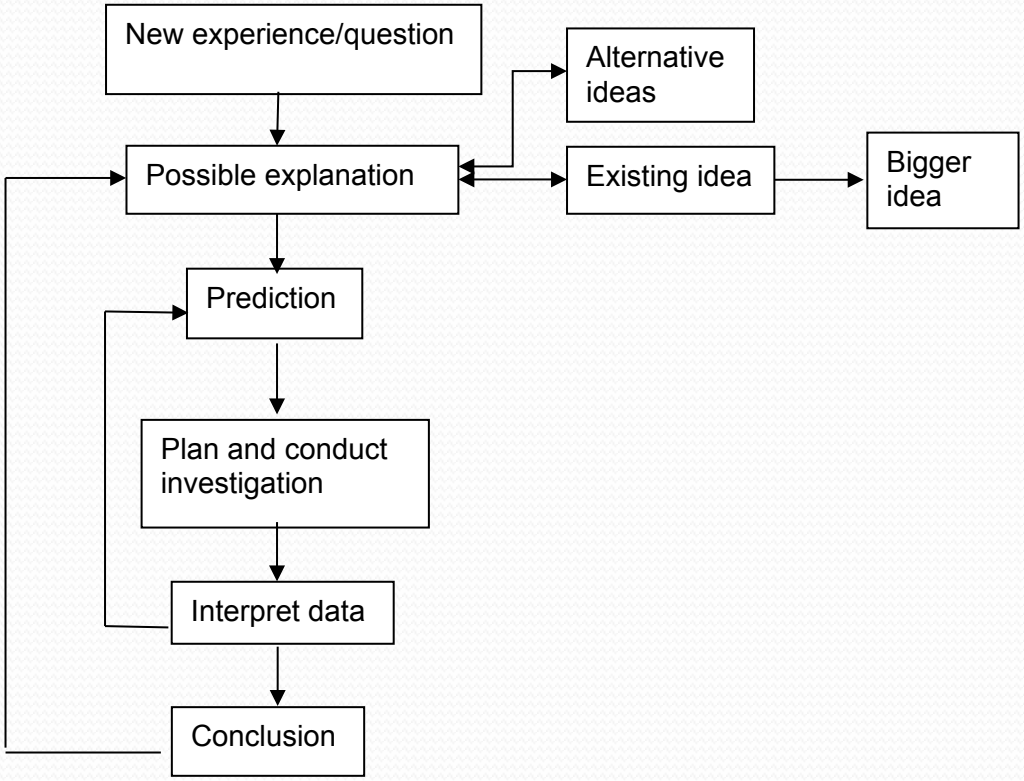
Agenda

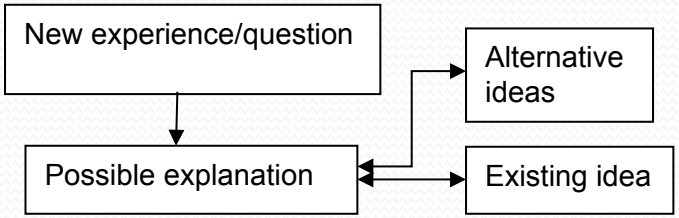
- Importance of IBSE
- Developing understanding through IBSE
- IBSE in practice
- Key challenges to implementation
- A curriculum based on ‘big’ ideas
- Assessment that helps learning

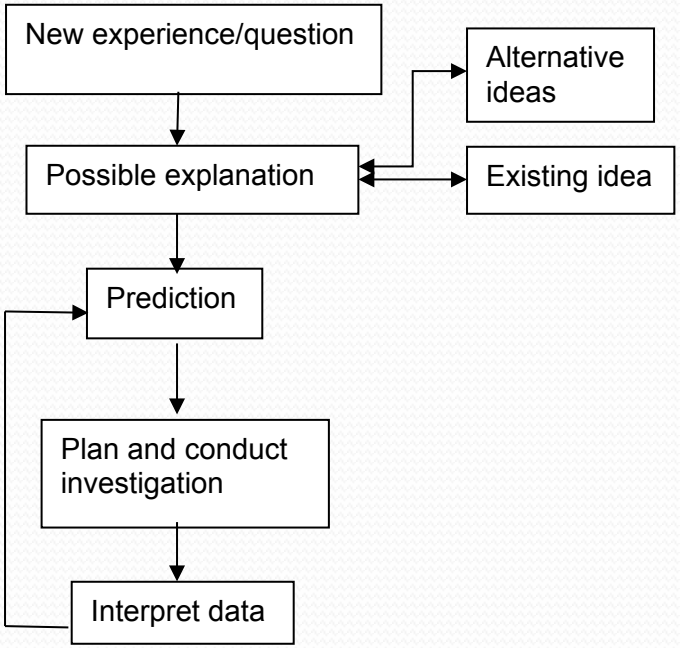
The importance of IBSE: developing understanding

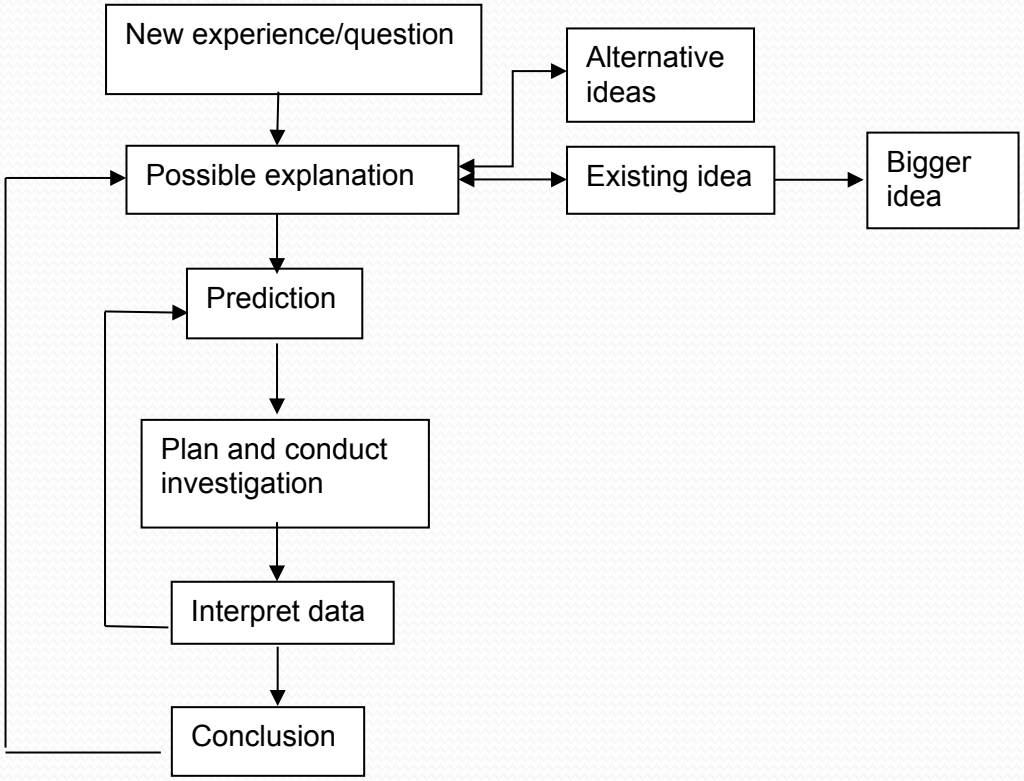
- Understanding requires the active engagement of learners
  - Starts from the ideas they already have
  - Involves testing their own and other's ideas through collecting evidence, analysing and interpreting, discussing, arguing from evidence, drawing defensible conclusions
  - Inquiry-based **science** education means students progressively developing key scientific ideas through learning how to investigate and build their knowledge and understanding of the world around.

How does inquiry promote understanding?




New experience/question
Alternative ideas
Possible explanation
Existing idea


New experience/question
Alternative ideas
Possible explanation
Existing idea
Prediction
Plan and conduct investigation
Interpret data

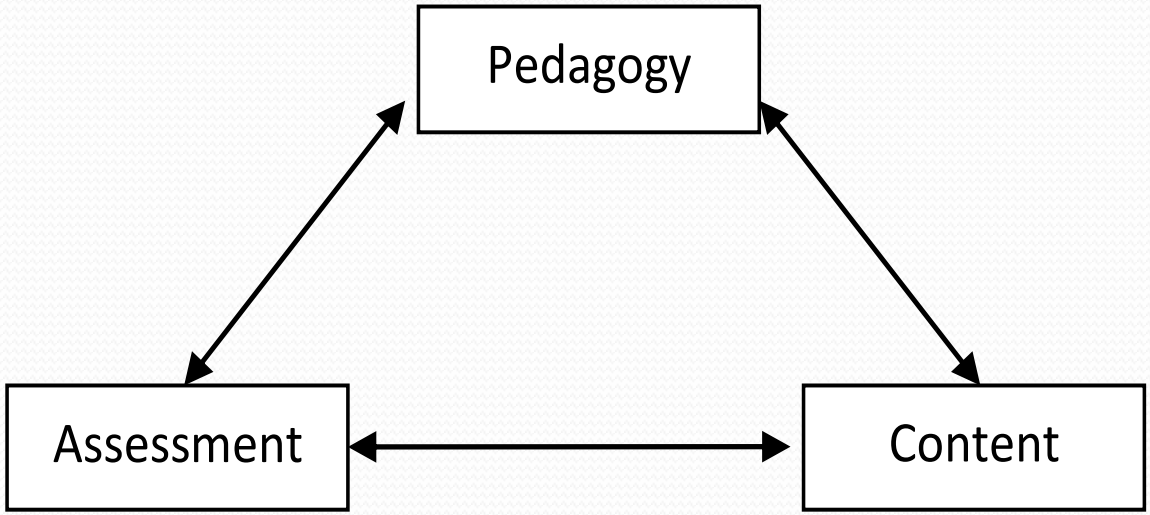


(Based on Harlen, 2006)

Teaching for understanding through inquiry

- asking the kind of questions that probe students' ideas
- encouraging students to ask questions
- asking for predictions
- enabling students to take part in planning investigations
- helping them to analyse and interpret their findings
- requiring students to compare what they find with what they predicted or expected and with what others have found
- encouraging students to draw conclusions and try to explain what they have found
- providing time to reflect on what they have found and done.

Interactions among key aspects of students' classroom experience



Curriculum content: common problems

- The science curriculum is often over-crowded and over-specified
- There is too much to 'cover' so memorisation replaces understanding
- Students' perspective:
  - Science seen as fragmented; no coherent picture emerging; 'not relevant!'
  - Students don't see how classroom activities help to explain things they find important.

Part of the solution (not a magic bullet)

- To conceive the goals of science education NOT as a collection of facts and theories, but rather as progress towards key ideas, meaning:
  - ideas that are of relevance to students' lives during and beyond school
  - ideas that progress from 'small' to 'big', helping learners make sense of their expanding experiences
  - ideas that provide a map for curriculum developers and teachers to select or create significant learning experiences from the enormous range available.

‘Small’ and ‘big’ ideas

- Small idea – *earth worms are suited in their form and function to living in the soil*
- Big idea – *organisms have evolved over very long periods of time to function in particular conditions*
  - Big ideas can be developed through a variety of content
  - Big ideas enable learners to understand events and phenomena as yet unknown to them
  - Big ideas ‘are ideas that can be used to explain and make predictions’
  - The more that is explained, the more powerful the idea.

How to identify big ideas?

- There is no single ‘right’ list to be uncovered
- Use experience and expertise of scientists, science educators and engineers
- Establish agree criteria
- Make judgements about the number and extent of selected ideas
- Validate with scientific community.


The experts who developed the Big Ideas of Science Education in 2014

Selection criteria

- Wide explanatory power
- Related to understanding issues related to decisions in everyday life (eg energy)
- Provide enjoyment, satisfaction
- Cultural significance (reflecting science as a human endeavour).

10 ideas *of* science

1. All matter in the Universe is made of very small particles.
2. Objects can affect other objects at a distance.
3. Changing the movement of an object requires a net force to be acting on it.
4. The total amount of energy in the Universe is always the same but can be transferred from one energy store to another during an event.
5. The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.
6. Our solar system is a very small part of one of billions of galaxies in the Universe.
7. Organisms are organised on a cellular basis and have a finite life span.
8. Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.
9. Genetic information is passed down from one generation of organisms to another.
10. The diversity of organisms, living and extinct, is the result of evolution.

Four ideas *about* science

11. Science is about finding the cause or causes of phenomena in the natural world.

12. Scientific explanations, theories and models are those that best fit the evidence available at a particular time.

13. The knowledge produced by science is used in engineering and technologies to create products to serve human ends

14. Applications of science often have ethical, social, economic and political implications.

7 Organisms are organised on a cellular basis and have a finite life span

All organisms are constituted of one or more cells. Multi-cellular organisms have cells that are differentiated according to their function. All the basic functions of life are the result of what happens inside the cells which make up an organism. Growth is the result of multiple cell divisions.

5-7

There is a wide variety of living things (organisms), including plants and animals. They are distinguished from non-living things by their ability to move, reproduce and react to certain stimuli. To survive they need water, air, food, a way of getting rid of waste and an environment which stays within a particular range of temperature. Although some do not appear to be active, all will at some stage carry out the life processes of respiration, reproduction, feeding, excretion, growth and developments and all will eventually die.

7-11

All living organisms are made of one or more cells, which can be seen only through a microscope. All the basic processes of life are the results of what happens inside cells. Cells divide to replace aging cells and to make more cells in growth and in reproduction. Food is the energy source they need in order to carry out these and other functions. Some cells in multi-cellular organisms, as well as carrying out the functions that all cells do, are specialised; for example, muscle, blood and nerve cells carry out specific functions within the organism.

11-14

Cells are often aggregated into tissues, tissues into organs, and organs into organ systems. In the human body, systems carry out such key functions as respiration, digestion, elimination of waste and temperature control. The circulatory system takes material needed by cells to all parts of the body and removes soluble waste to the urinary system. Stem cells, which are not specialised, are capable of repairing tissues by being programmed for different functions. Cells function best in certain conditions. Both single cell and multi-cellular organisms have mechanisms to maintain temperature and acidity within certain limits that enable the organism to survive.

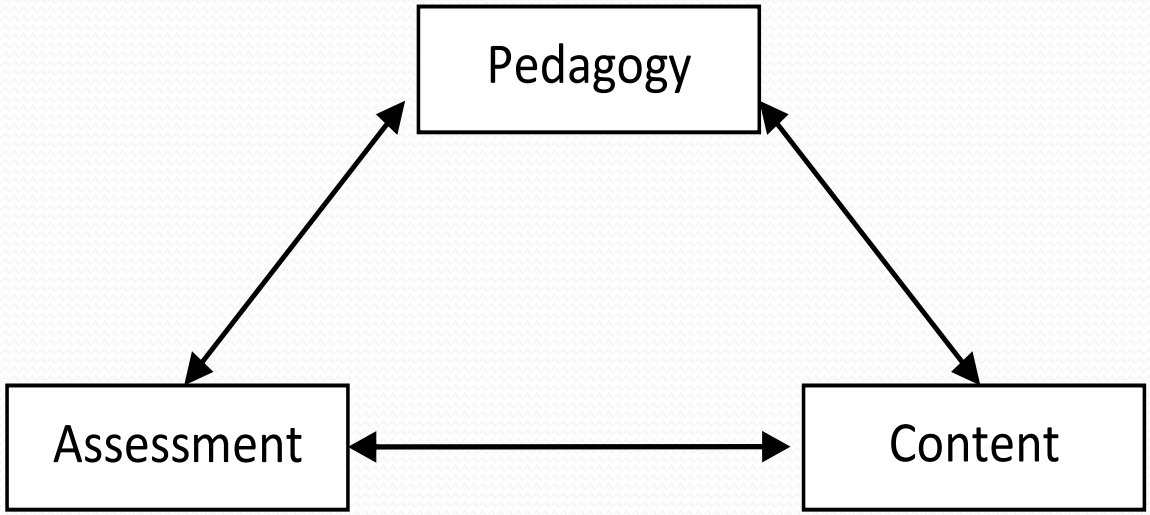
14-17

Within cells there are many molecules of different kinds which interact in carrying out the functions of the cell. In multi-cellular organisms cells communicate with each other by passing substances to nearby cells to coordinate activity. A membrane around each cell plays an important part in regulating what can enter or leave a cell. Activity within different types of cell is regulated by enzymes. Hormones, released by specialised tissues and organs, regulate activity in other organs and tissues and affect the overall functioning of the organism. In humans, most hormones are transported in the blood. Many medicines operate by speeding up or slowing down the regulatory mechanisms of enzymes or hormones. The brain and spinal cord also contribute to the regulation of cell activity, by sending messages along nerve cells in the form of electrical signals, which travel quickly between cells.

Given a suitable medium, cells from a variety of organisms can be grown *in situ*, that is, outside the organism. These cell cultures are used by scientists to investigate cell functions, and have medical implications such as the production of vaccines, screening of drugs, and in vitro fertilisation. Plant tissue culture is used widely in the plant sciences, forestry, and in horticulture.

Most cells are programmed for a limited number of cell divisions. Diseases, which may be caused by invading microorganisms, environmental conditions or defective cell programming, generally result in disturbed cell function. Organisms die if their cells are incapable of further division.

Interactions among key aspects of students' classroom experience



Assessment of students: some common problems

- Assessment is dominated by tests
- Tests concern factual knowledge
  - encouraging teaching of disconnected facts
  - discouraging inquiry-based/evidence-based teaching
- Often what is assessed does not match what ought to be assessed
- The potential for using assessment to help learning is not realised.

Main reasons for assessing students' learning

- To gather and use information about students' ideas and skills to help learning (formative assessment - or assessment *for* learning).
- To find out and report on what has been learned at a particular time (summative assessment – or assessment *of* learning)

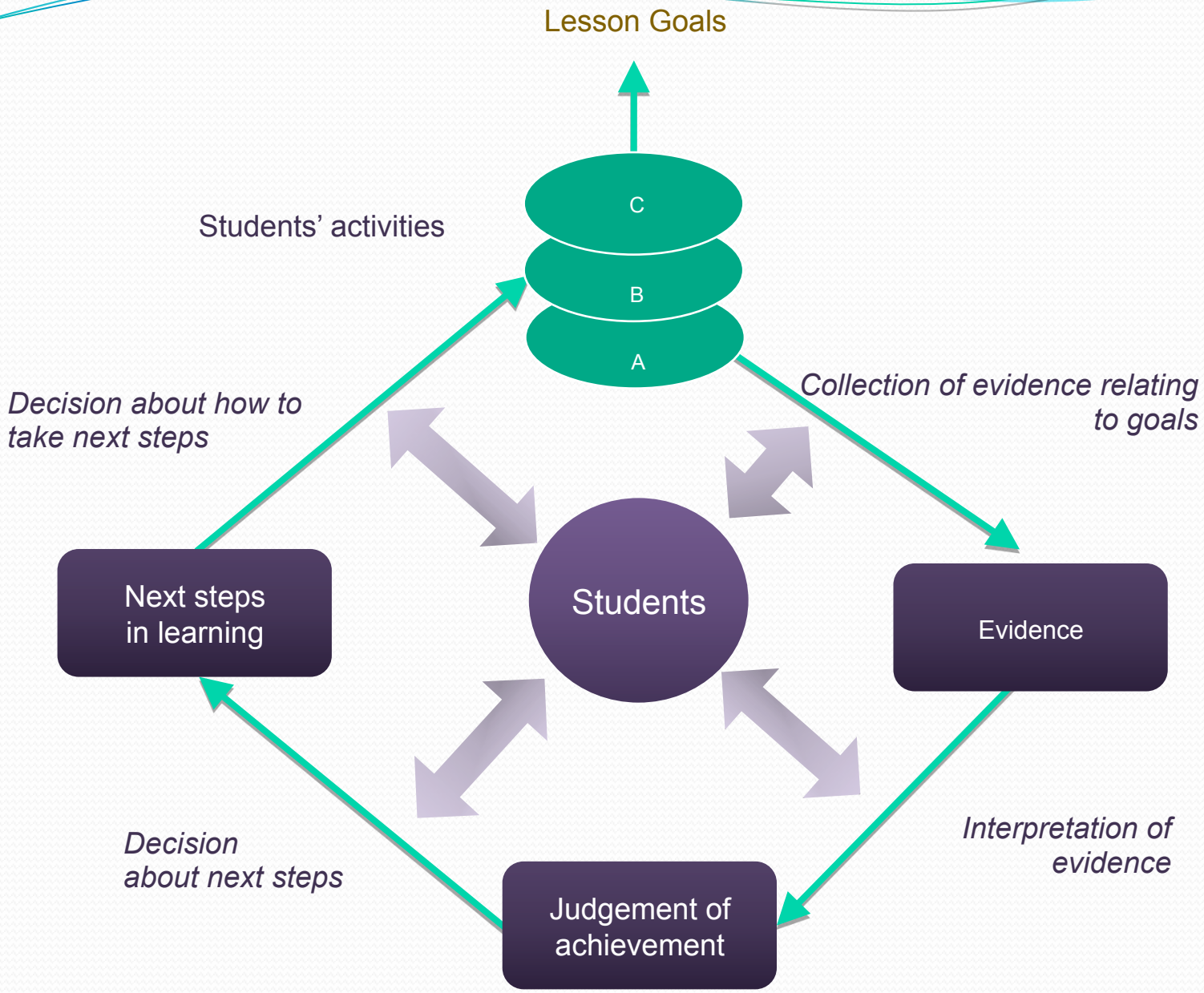
The challenge of assessing goals of IBSE

- Students must be engaged in using inquiry skills and competences in order to assess their progress in IBSE
- Inquiry in science must involve some science content combined with general (generic) inquiry skills that can be applied in any domain of inquiry
- The context and subject matter in which inquiry is used influences students' performance.

Formative assessment

- A continuing cyclic process in which information about students' ideas and skills informs on-going teaching and helps learners' active engagement in learning.
- Involves the collection, interpretation and use of evidence about learning as it takes place.
- Identifies appropriate next steps and how to take them.
- Provides feedback to students and teachers to ensure progression in learning.
- Regulates the teaching and learning processes to ensure learning with understanding, by providing feedback to both teacher and student.

Model of formative assessment



Why is it important?

- Review of research (Black & Wiliam (1998)) shows:
  - Implementing formative assessment can raise student achievement
  - The effect is larger than for any other intervention
  - Lower-achieving students gain most
  - The gap between higher and lower achieving students is decreased

Formative assessment is integral to inquiry-based teaching and learning

Summative assessment

- Judgement relating to achievement of goals of a course
  - (cf formative where judgement is about achievement of topic or lesson goals)
- Reporting takes place at the end of a unit of work or stage of learning
  - (cf formative where feedback is given regularly)
- Usually obligatory
  - (cf formative which is essentially voluntary)

Uses of summative assessment data

- In contrast with formative assessment, which has one use, the results of summative assessment can be used in many different ways:
  - Within school, for grading, record keeping, informing parents and students about progress
  - By external bodies, for certification, selection, qualifications
  - For accountability, for evaluation of teachers, schools, administrative authorities
  - For monitoring, locally, nationally, internationally, by sampling (eg TIMSS, PISA)
  - etc

Summative assessment: how?

- Evidence collected by
  - Tests – internally or externally set, internally or externally marked
  - Summary of observations made by teacher (for formative assessment) judged by teacher
  - Judgement of portfolio of work selected by teacher/ student
  - Embedded tasks observed/marked by teacher
  - Computer-based tasks
  - Combination or variations of these.

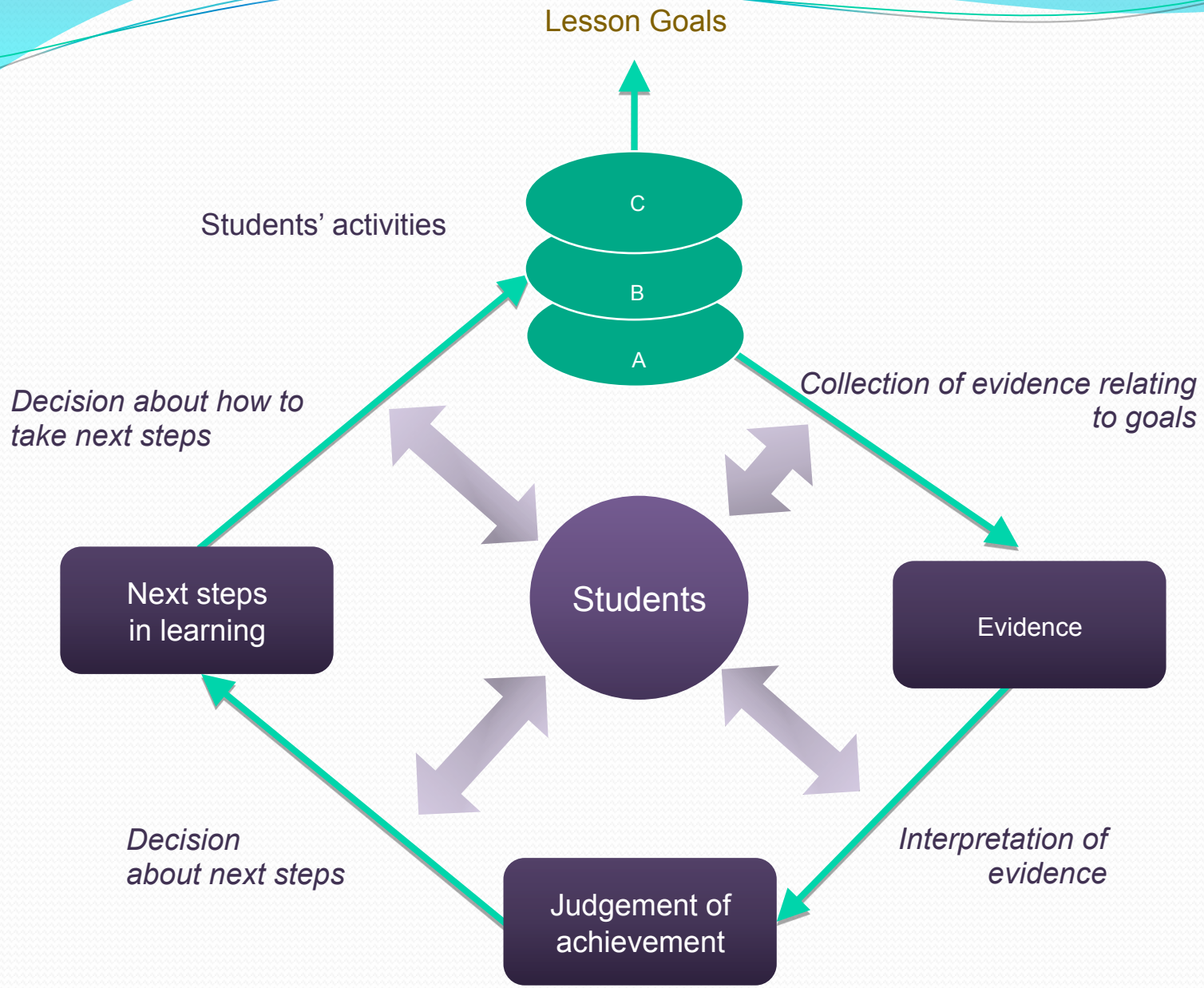
Problems with tests

- Limited number of items – results may be different for different samples of items
- Preference for reliably marked items reduces validity – trade-off between validity and reliability
- Context effect in assessment of competences/skills
- Separate skills rather than whole investigations
- Difficulty of ensuring application rather than recall
- Other features of context (beyond familiarity) may affect engagement
- High stakes uses of results leads to 'teaching to the test'
- Put students and teachers under pressure.

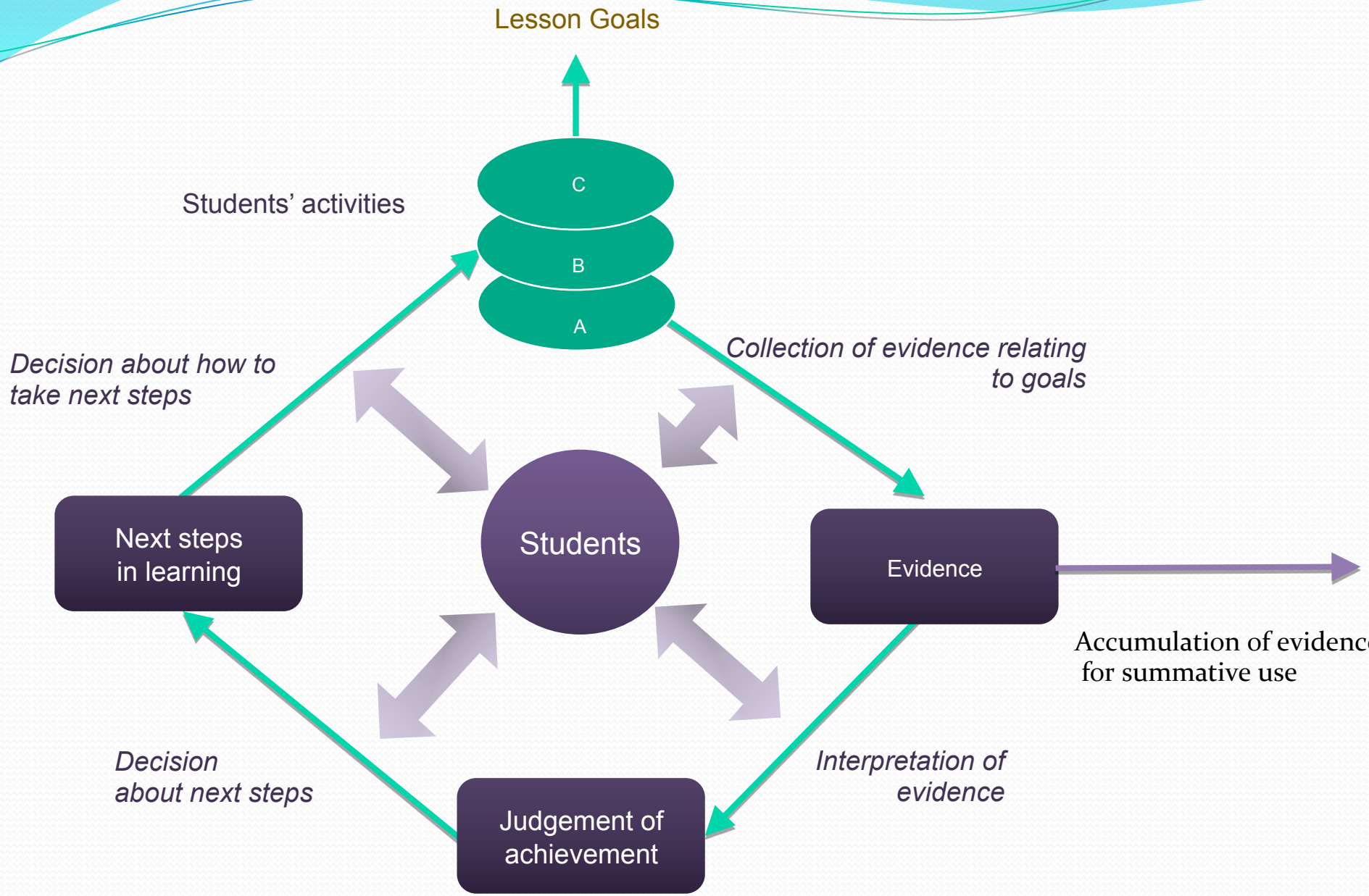
Alternatives to tests

- Inquiry-based classroom science activities provide opportunities for **teachers** to collect data for assessment of
  - inquiry skills
  - scientific understanding
  - understanding of how science works
- In real contexts which
  - engage their thinking
  - enables development of their understanding of big ideas.

Model of formative assessment



Model of formative assessment



Using formative assessment data for summative assessment

- Using formative assessment provides information about on-going learning – of the full range of learning goals
- This information can be scanned and summarised for reporting at certain stages in terms of the stage goals
- In this way the rich data gathered and used during learning can be used of summative reporting.

Increasing the reliability of assessment by teachers

- Moderation procedures
  - Provision of detailed progressive criteria
  - Exemplification – 'worked examples'
  - Group discussions of assessed work
  - Standardised tasks or short tests used to check judgements.

Thank you