Building a STEM curriculum unit framework

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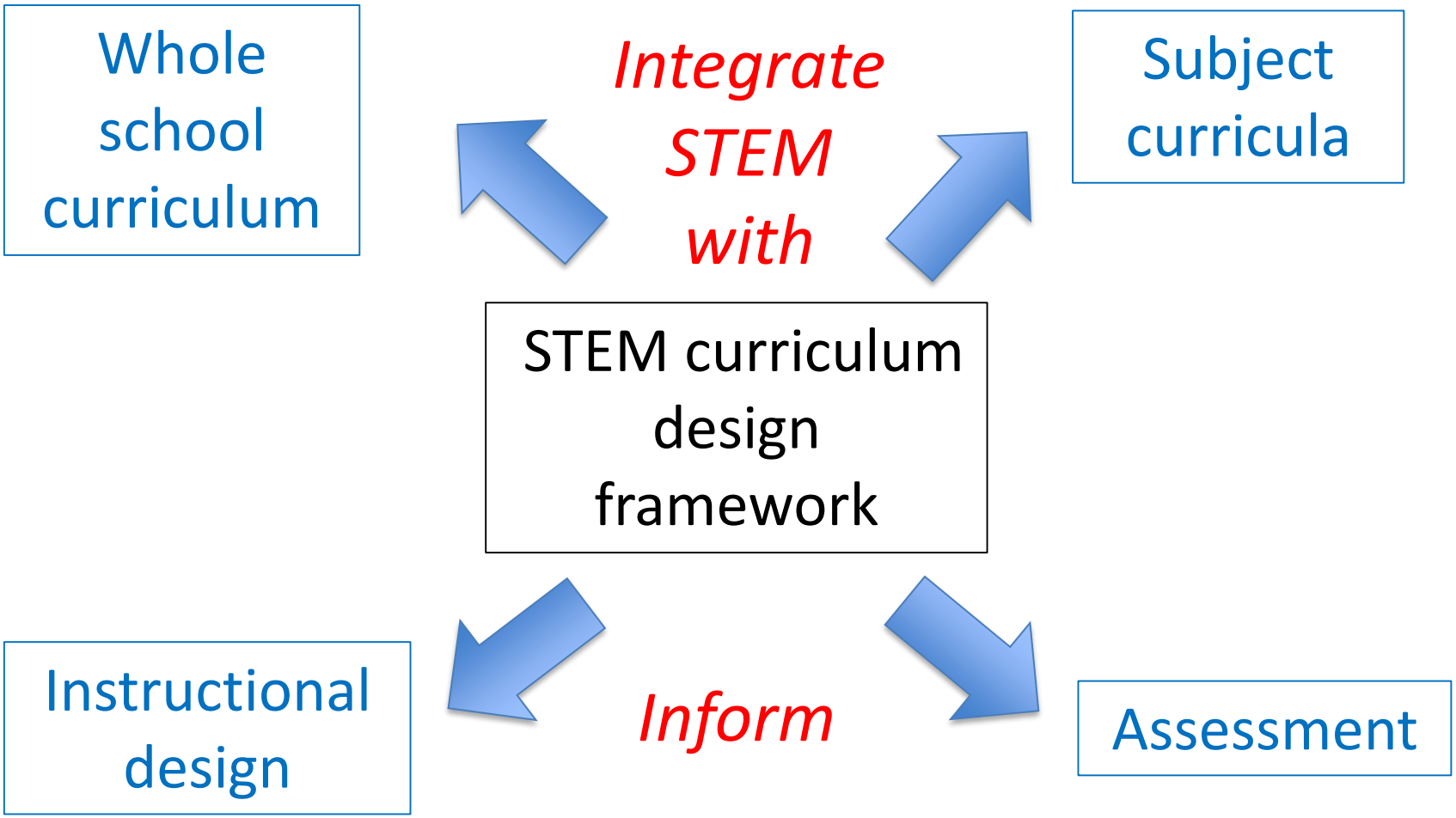
The bottleneck of STEM education

1. What could students learn through STEM ?
2. How to achieve ‘STEM for All’?
3. How could STEM and subject learning complement each other?
4. How could STEM contribute to the overall school curriculum?

The need for a STEM curriculum framework

Building a STEM curriculum *'design'* framework

How could a STEM curriculum design framework help?



Aim of this workshop

You will go through

- a construction process

  →to build a framework for designing a school-based STEM curriculum unit

What is a curriculum unit?

Subject (Long-term)

Activity (Short-term)

What count as STEM education

STEM Subject curricula	Integrated STEM
• Out of context, irrelevant to daily life • Narrow aims – emphasize low-order thinking • Textbook-led, passive learning • Compartmentalization of knowledge • Creativity and innovation under-emphasized	• Contextual, related to daily life • Problem-based • Integrated application of knowledge and skills of different disciplines • Applying technology • Developing higher order thinking (e.g., creating)

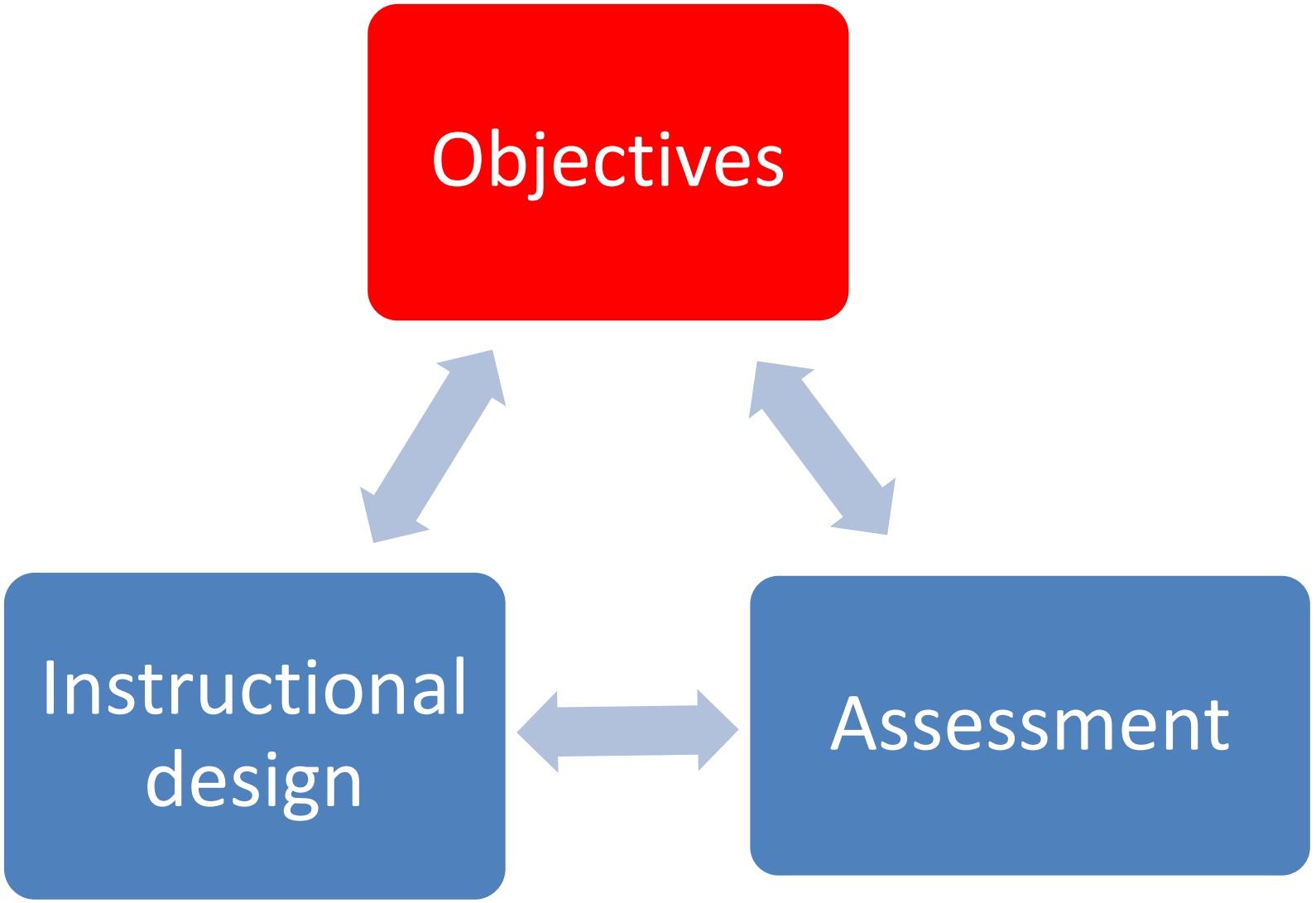
Constructing a STEM curriculum unit
at
ABC School

A role-play

Subject Panel meetings

Primary Section	Secondary Section
GS (Science)	Science
GS (Technology)	IT/Computer
Computer	D&T (other technology subjects)
Mathematics	Mathematics

Designing a curriculum



Subject Panel meeting

Agenda:

1. Discuss and identify 6 objectives for your subject
2. Write each objective on a small piece of paper*

3. Organize your objectives into 6 cognitive levels (according to the revised Bloom's taxonomy)
4. Stick your objectives onto the Bloom taxonomy table (1) provided*

Revised Bloom's taxonomy (Cognitive domain)

6 levels of cognitive processes:

- Remember (記憶)
- Understand (理解)
- Apply (應用)
- Analyse (分析)
- Evaluate (評鑑)
- Create (創造)

Revised Bloom's Taxonomy

Advantages –

- applicable to all subjects
- Can differentiate low-order and high-order thinking skills

Limitation -

Only deal with cognitive objectives

3. Organize your objectives into 6 cognitive levels (according to the revised Bloom's taxonomy)
4. Stick your objectives onto the Bloom taxonomy table (2) provided*

學科：_____

Remember (記憶)	
Understanding (理解)	
Apply (應用)	
Analyze (分析)	
Evaluate (評鑑)	
Create (創造)	

5. Discuss: Are there any levels without objectives?

6. Fill in those ‘missing data’ to complete your objectives table

7. Make a copy of the full set of objectives for each panel member.

The School STEM Team

Re-organize the subject panels into 4 STEM teams with representatives from the four subjects

STEM Team Meeting

Agenda:

1. Combine the four subjects' objectives by sticking them onto the Bloom's Taxonomy chart provided*

   (Each member to brief the other members about their subject objectives)

	學科 1	學科 2	學科 3	學科 4	____
Remember (記憶)					
Understanding (理解)					
Apply (應用)					
Analyze (分析)					
Evaluate (評鑑)					
Create (創造)					

2. Discuss: Is your combined table sufficient to represent a STEM curriculum? If not, what is missing?

3. Reorganize your subject objectives into the four domains of STEM to form a *'STEM Objectives Table'**
4. Supplement the objectives of each domain if necessary (e.g., engineering)

	S	T	E	M	___
Remember (記憶)					
Understanding (理解)					
Apply (應用)					
Analyze (分析)					
Evaluate (評鑑)					
Create (創造)					

Analysis of STEM activities

5. Examine STEM activity 1. Identify the objectives of the activity from your *'STEM Objectives Table'*.
6. Decide whether you would like to revise your *'STEM Objectives Table'* after identifying all the objectives of that activity.

STEM Team Meeting

Agenda:

7. Repeat (5) and (6) with STEM activity 2.

STEM Team Meeting

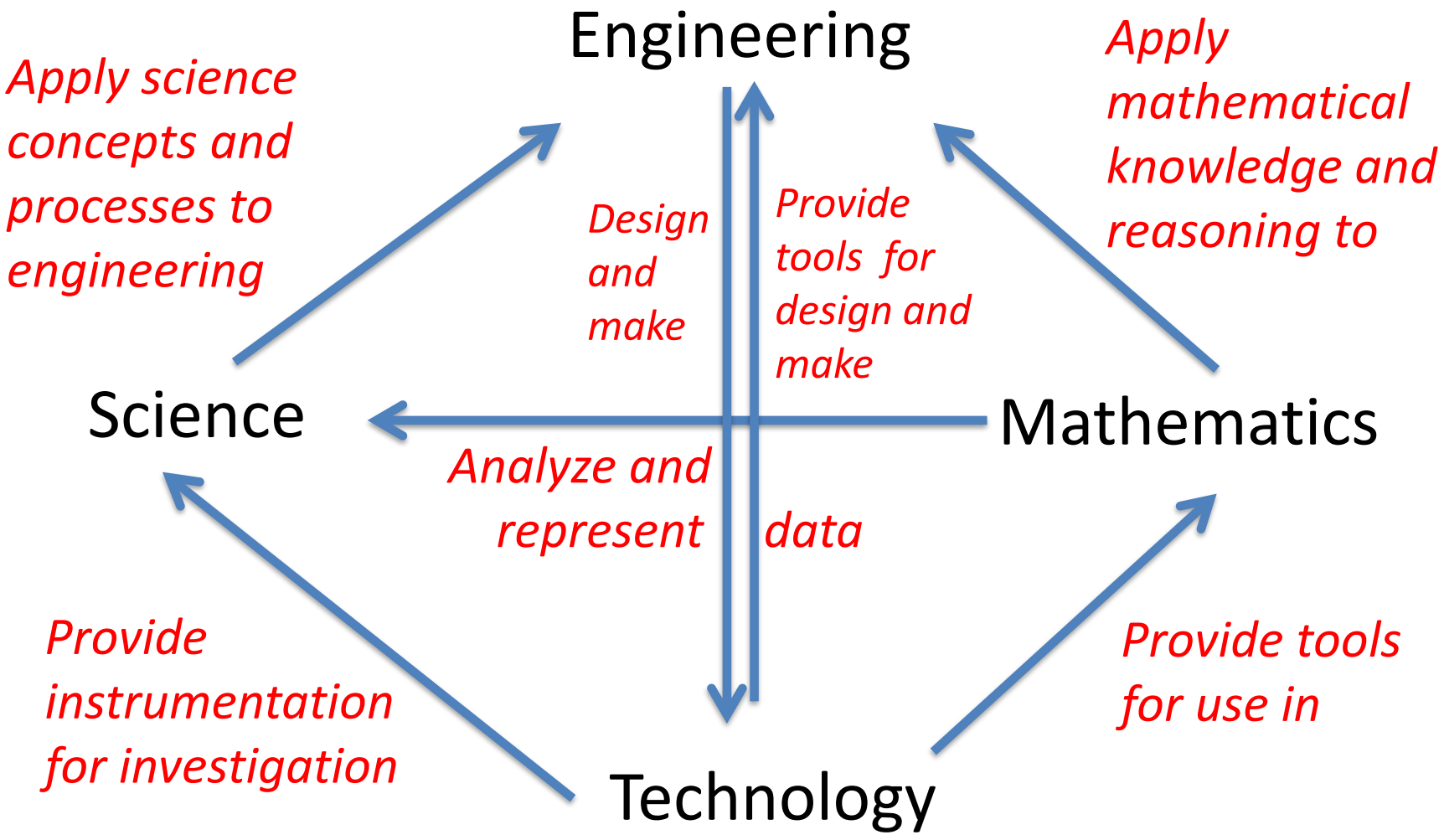
Agenda:

8. Compare and contrast the objectives of the two activities.
9. Discuss:

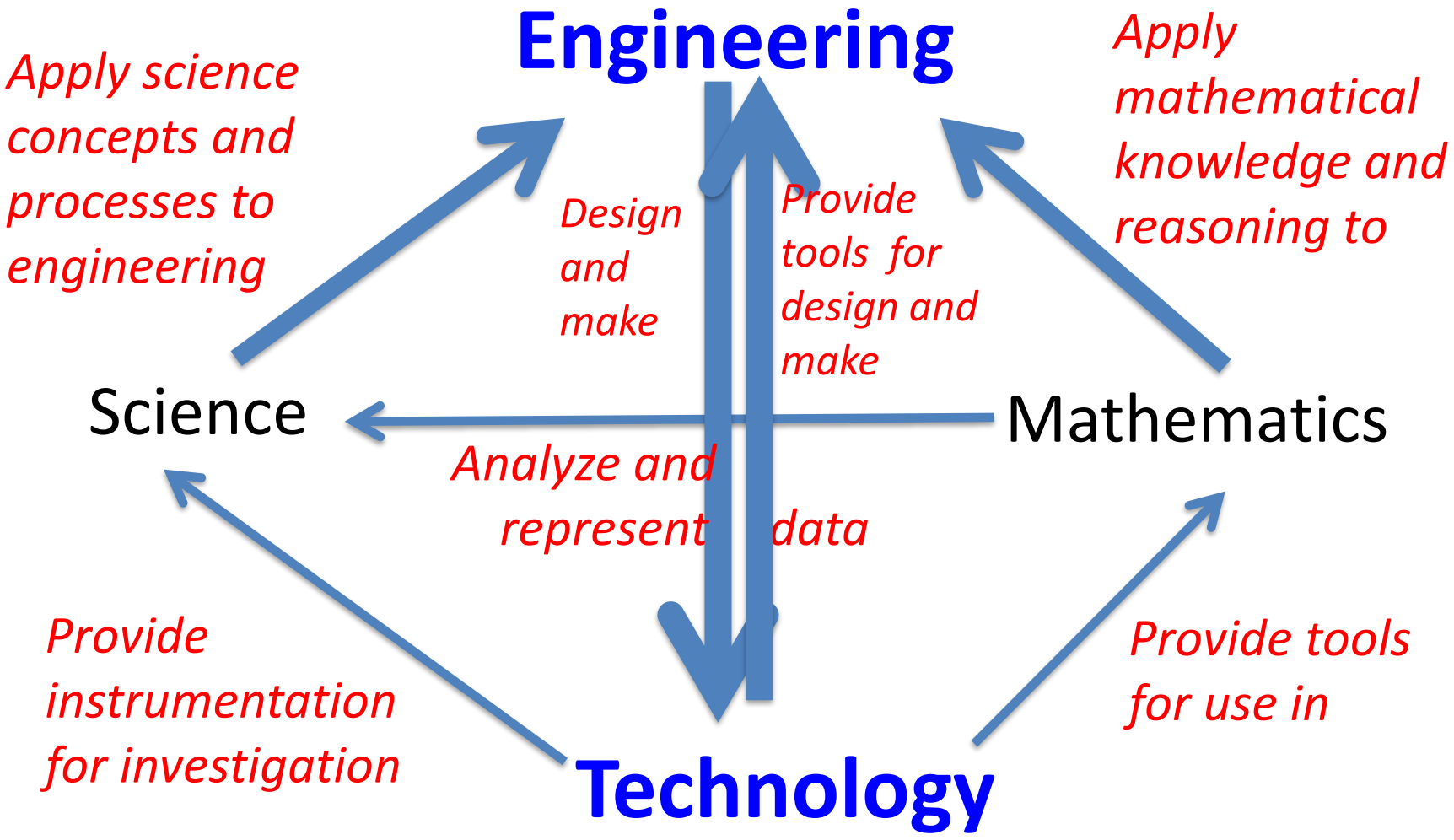
- How do the objectives of the two activities bring together S, T, E and M?

Building linkages across S/T/E/M

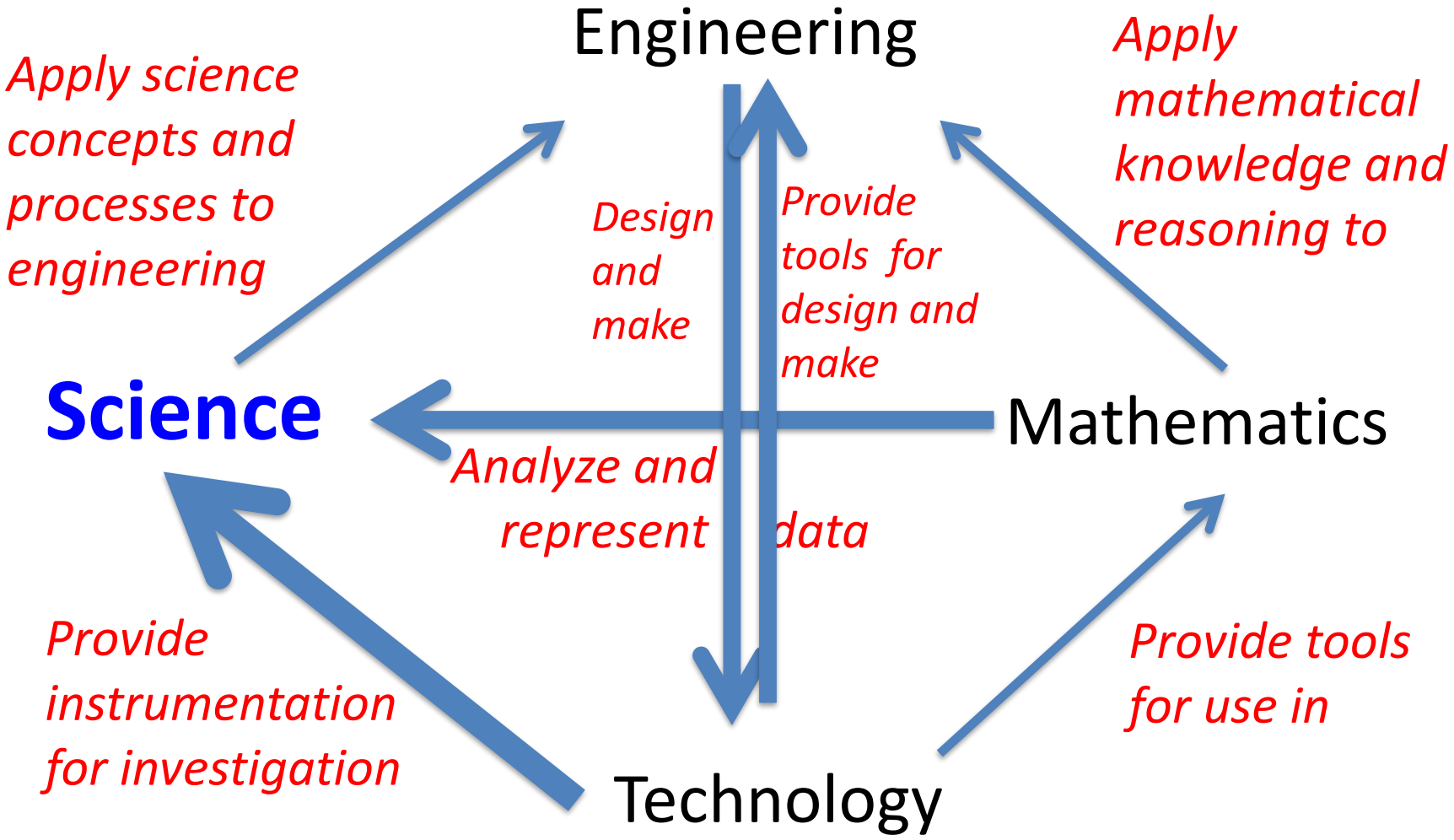
Connecting S, T, E and M



Case 1: Making a device for airdrop

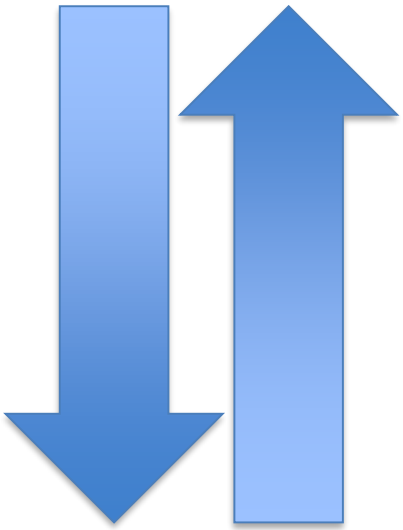


Case 2 – Investigating the effect of soil moisture on crop growth



STEM objective design at two levels:

Activity-specific



Generic

More to the learning outcomes

Other learning outcomes of Integrated STEM education

- Types of knowledge:
  - Cognitive
    - Factual
    - Conceptual
    - Procedural
  - Metacognitive*
- 21st century skills*
- Attitudes (attitudes unique to each subject/ attitudes toward STEM subjects.)*

Metacognitive knowledge (後設認知知識)

1. Understanding strategies for learning, thinking and problem solving
2. Understanding strategies for performing different cognitive tasks
3. Awareness of one's strengths, weaknesses and abilities in applying those strategies

Metacognitive knowledge --------> SDL

(Self-directed learning)

21st century skills

- Communicating information, ideas, designs/solutions and arguments
- Critical reasoning and argumentation
- Collaborating with peers
- Problem solving
- Creativity and innovativeness
- Self-learning, self-monitoring, self-reflecting and self-regulating

Affective Domain

Attitudes (related to disciplines)

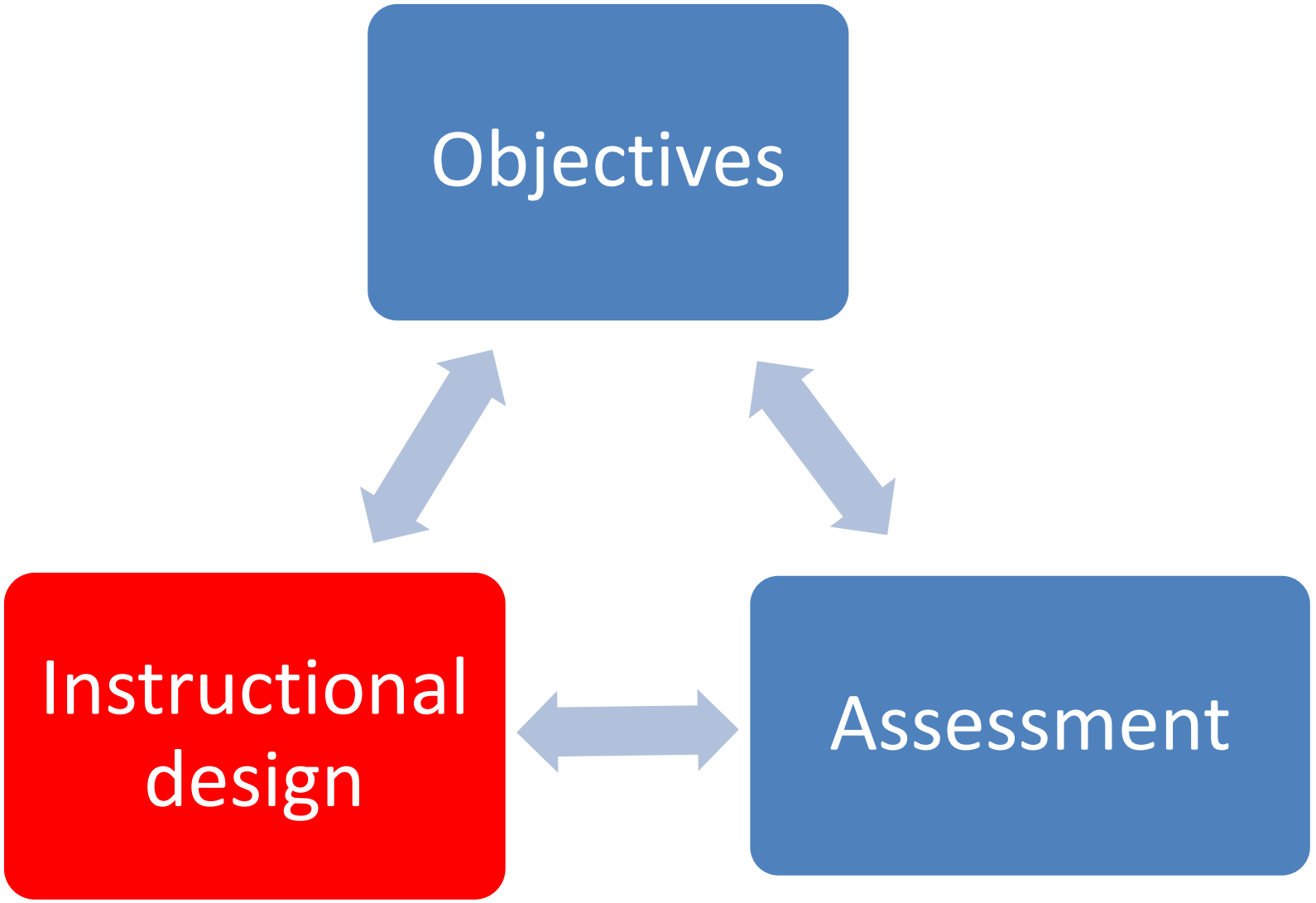
- Objective, able to tolerate ambiguity or uncertainty, curiosity, honesty, striving for optimization, open-minded, willing to take risks, being precise and reflective

Attitudes toward STEM

- Interest, willingness to participate, valuing, persevering, self-confidence, feeling satisfied

From objectives to instructional design

Designing a curriculum



- Discuss: What are the areas that you need to consider in planning for your instructions?

A TWO-step process

Step One: Determine the nature of the activity/project

- Orientation of the activity
  - Design-based / Inquiry-based?
- Use of technology
  - Programming / Micro-controller / Crafts
- Curriculum context
  - Formal / Informal / Mixed
  - Single subject / Cross-subjects
- Problem context
  - Science / Environment / Art / Social / Historical…..

Step Two: Instructional design

1. Aligning instructional design with your objectives
2. Designing your instructional plan

1. Aligning instructional design with the objectives

- Designed-based activities (e.g. *'Airdrop')*
  - Match your STEM objectives to the different stages of the design cycle.

- Inquiry-based activities (e.g., *'Soil Moisture')*
  - Match your STEM objectives to the different stages of the scientific investigation process.

《高空擲冰》（高小）

工程設計為本活動

學科 / 工程設計	構想意念	進行研究	制定設計	製作模型	測試模型	分析及檢討	改良設計
M 數學					*量度不規則形狀的體積的方法*	將實驗結果以統計圖展示	
E 工程	構想空投裝置(	分析任務，訂定工作的具體項目(前期)；	應用科學、數學及科技概念進行設計；	*參考設計循環進行設計及製作，包括繪畫設計圖等，進行保溫及撞擊測試等*		決定設計能否達標 釐定對設計的不同要求的優先次序；	
S 科學		熱傳遞 導熱體和絕緣體 空氣阻力 避震			*應用公平測試方法*		

《濕好定乾好？》(初中)

科學探究為本活動

	界定問題	提出假設	設計實驗	觀察量度	記錄數據	分析數據	評鑑實驗	作出結論
M **數學**						將實驗結果以統計圖展示		
T **科技**			編程概念； 感應器，馬達(Servo motor)，Micro:bit/Arduino 微控制器、麵包板及簡單電子元件的作用；					
E **工程**			應用科學、數學、編程及科技概念設計及製作濕度控制裝置；					
S **科學**		植物的生長特徵； 植物的生長條件； 閉合電路的運作原理	***何謂公平測試*** 策劃研究方案，以找出問題的答案	***進行公平測試***			評估實驗數據的可信性及誤差	

學科 / 科學探究

2. Designing instructional plan

Application of SDL in instructional design:

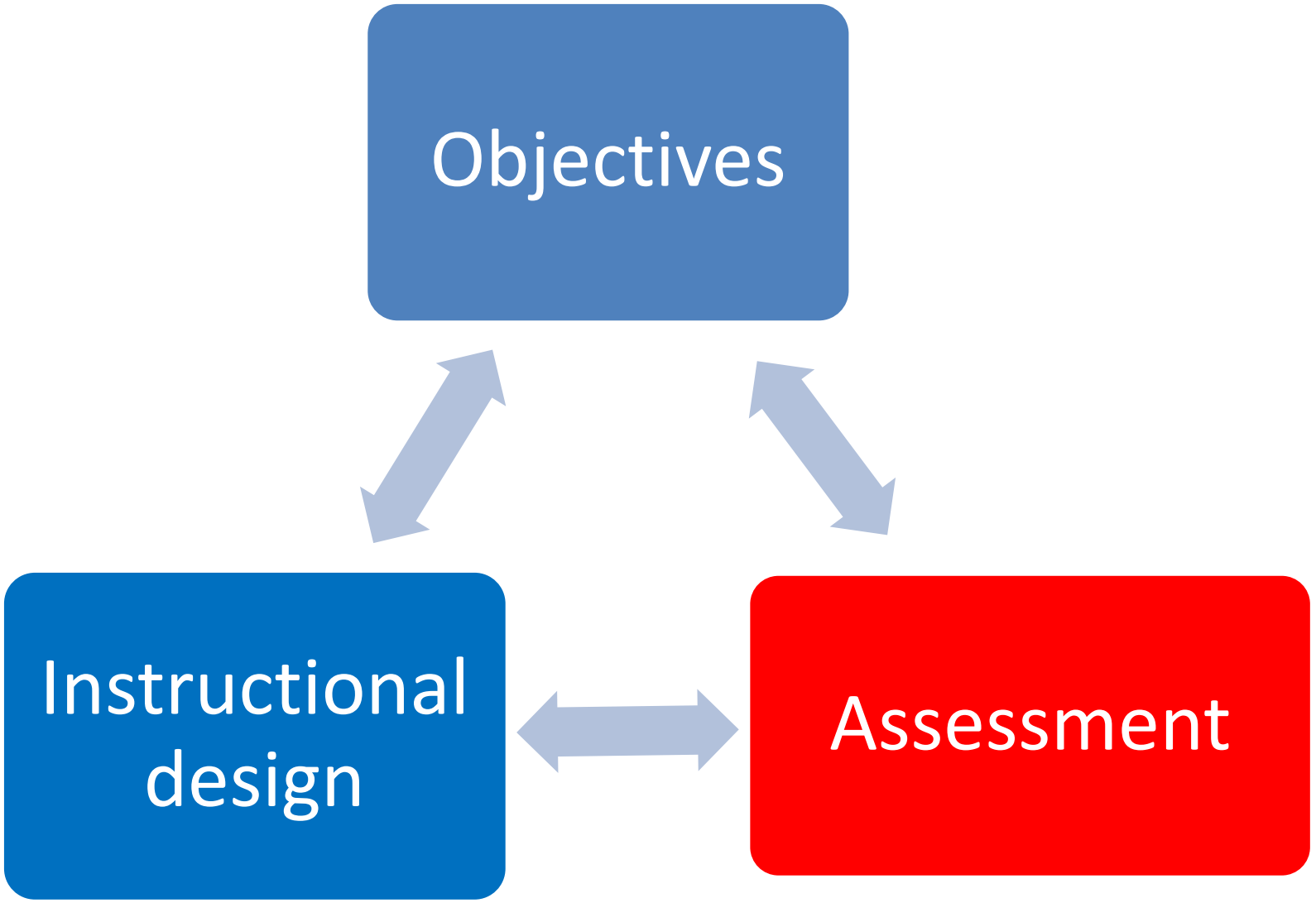
- Teacher-directedness Vs student-directedness

Aspects of instructional design:

- Teaching/learning approaches (e.g., SDL strategies)
- Scaffolding and learning flow
- Learning environment
- Resources
- Grouping
- Record and format of student work
- Dissemination/sharing of students' learning outcomes

From Instruction to Assessment

Designing a curriculum



Design of Assessment

- Purpose/timing of assessment
- Criteria for assessment
- Modes of assessment

School Education Goals

STEM subjects

Other Subjects

Cognitive Domain (Cognitive process)		STEM Learning objectives				
		S	T	E	M	Others
Remember	Factual knowledge* (F)	Scientific facts	Facts related to a technology (e.g., parts for making a technological device)		• Forms of mathematical representations • Measuring instruments	
Understand	Conceptual Knowledge^ (C)	Understanding scientific principles, theories, laws, mechanisms, relationships between structure and function	• Understanding how the role of technology in society • Understanding the relationships of technology with science and engineering	• Understanding the concepts of criteria and constraints • Understanding engineering systems/mechanisms (E.g., feedback control system)	Understanding different mathematical representations to represent variables and relationships	
	Procedural Knowledge# (P)	Understanding the scientific inquiry/research process and the skills involved	• Understanding the procedure for using specific technologies (e.g., ICT software) • Understand how to operate basic technological tools to make artifacts and/or facilitate scientific investigations	Understanding the engineering design cycle (e.g., how to research information required, make design sketches, and the iterative process of testing and refining solutions)	Understanding mathematical reasoning	
Apply	C	Making use of scientific principles to design investigations into natural phenomena	• Selecting technology devices or processes (including ICT) to collect and analyze data, or to solve problems; • Choosing suitable materials for making	Applying science, mathematics and engineering concepts and processes to solving a problem	Applying mathematical and computational reasoning • Choosing appropriate mathematical representations to	

Subject integration

Instructional design

Assessment