Scientific Argumentation & Drawing

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HOW SHOULD SCIENCE BE LIKE?

HOW SHOULD SCIENCE LEARNING BE LIKE?

LOOKING BACK HOW WE LEARN WHEN WE WERE A CHILD…

How about in class?

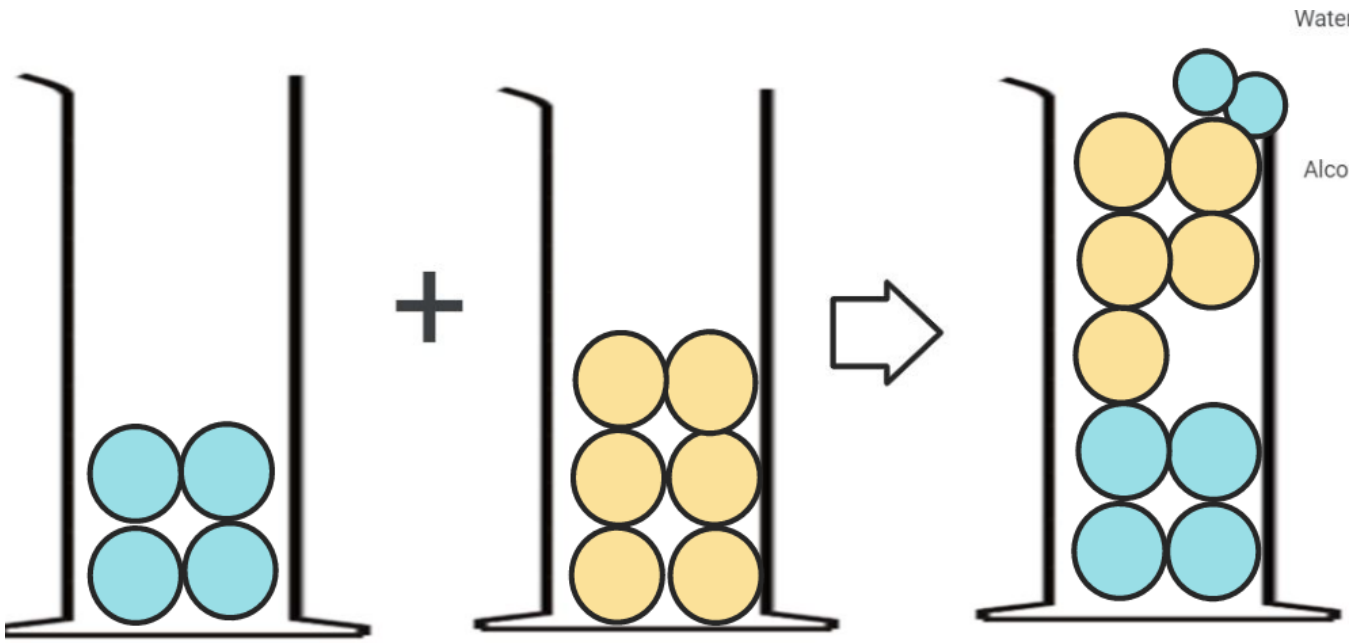
Does how teachers teach really matches the style of how students learn?

TO PROMOTE SCIENTIFIC ARGUMENT, WE HAVE TO FIRST PROVIDE AN AUTHENTIC SITUATION.

HOW ABOUT IN PARTICLE THEORY…

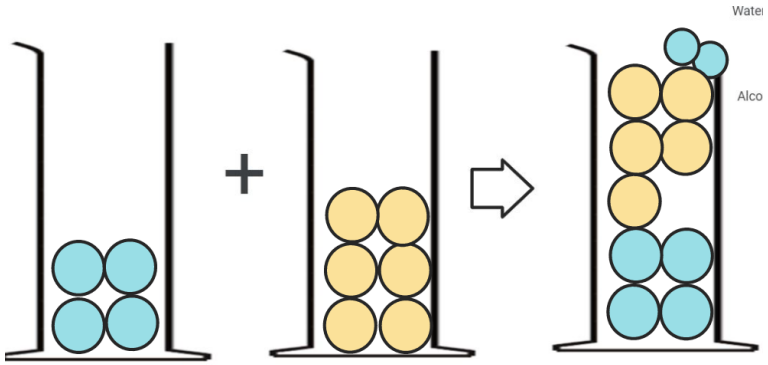
	Solid	Liquid	Gas
Arrangement of particles	Close together Regular pattern	Close together Random arrangement	Far apart Random arrangement
Movement of particles	Vibrate on the spot	Move around each other	Move quickly in all directions
Diagram			

WHEN STUDENTS ARE ASKED TO DRAW A PARTICLE MODEL TO REPRESENT WHAT HAD HAPPENED AFTER MIXING WATER AND ALCOHOL…



How would you response to that?

Teacher A:
This is wrong.



Teacher B:
This is wrong. The particles should be of the same size.

Teacher C:
Why do you think that?

Teacher D:
Why do you think that?...
Actually, the correct one should be…

CHANCES TO EXPRESS = CHANCES TO ENACT ?

Even when students are given chances to express their ideas, it doesn't mean they have the chance to build their arguments.

Need a change of how we teach.

CURRENT FLOW OF TEXTBOOK

INTRODUCTION OF PARTICLE THEORY

EXPERIMENTS TO VERIFY THE FACTS

Balloon and perfume
Bean and sago
State of matter
Dissolving

SUMMARY

CURRENT FLOW OF TEXTBOOK

Students take a passive role of learning.
Experiments serve as a verification of what the teacher just said
but not an evidence for students to generate/ revise their own knowledge.

INTRODUCTION OF PARTICLE THEORY

EXPERIMENTS TO VERIFY THE FACTS

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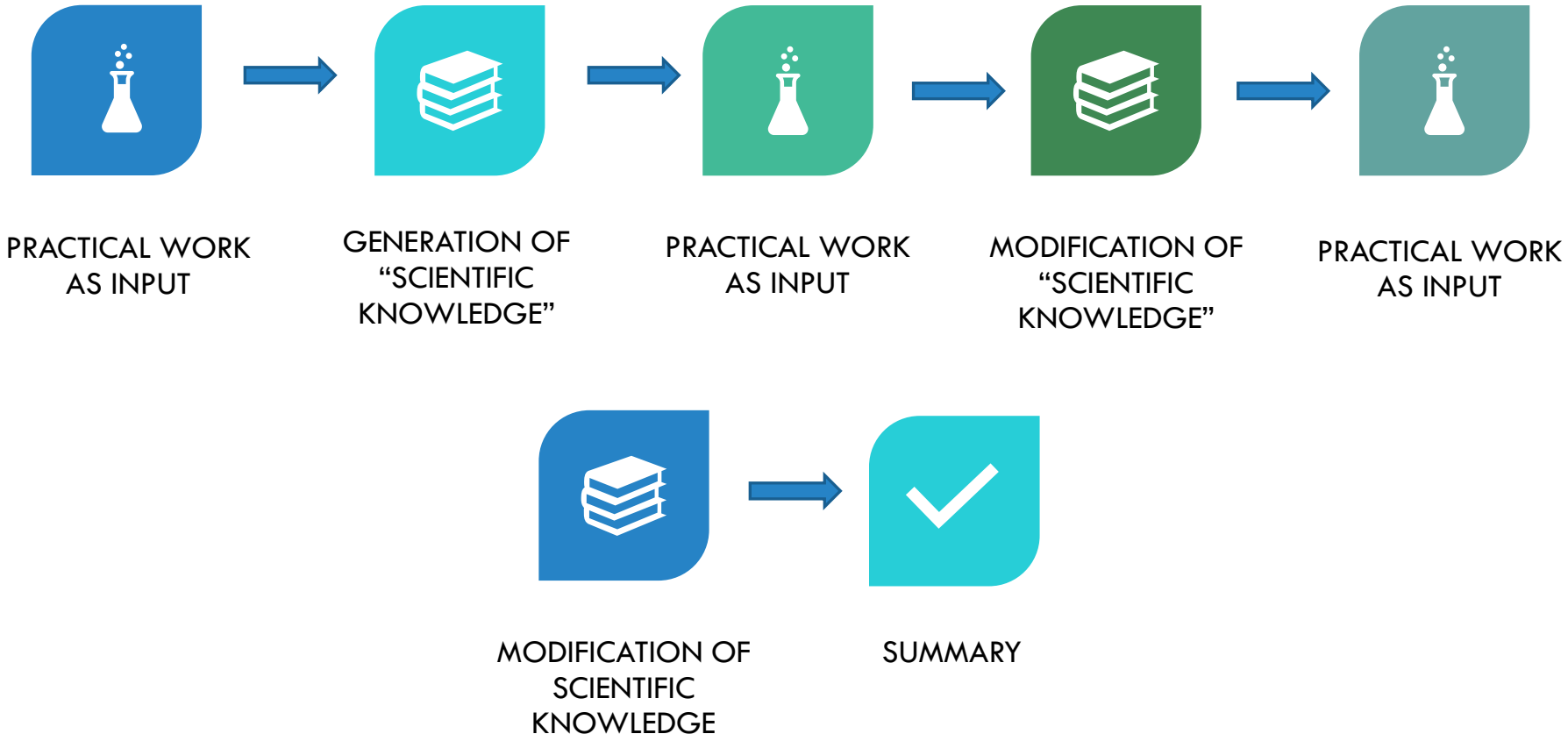
SUMMARY

AN ALTERNATIVE WAY OF PRACTICE



OVERVIEW OF THE SERIES

Lesson	Input	Modification
1-2	Introduction of particle Water + alcohol	Pre- explanation (Diagram) Post- explanation (Diagram)
3-4	Conservation of mass in mixing Balloon and perfume	Verbal explanation Explanation (diagram)
5-6	State of matter (incompressible nature of liquid)	Verbal explanation
7-8	Dissolving	Explanation (Diagram)

AN ALTERNATIVE WAY OF INTRODUCTION

- 50 ml water + 50 ml alcohol = ? ml

- Introduction of the idea of particle

- Asking students for prediction of the total volume after mixing 50 ml water and 50 ml alcohol.

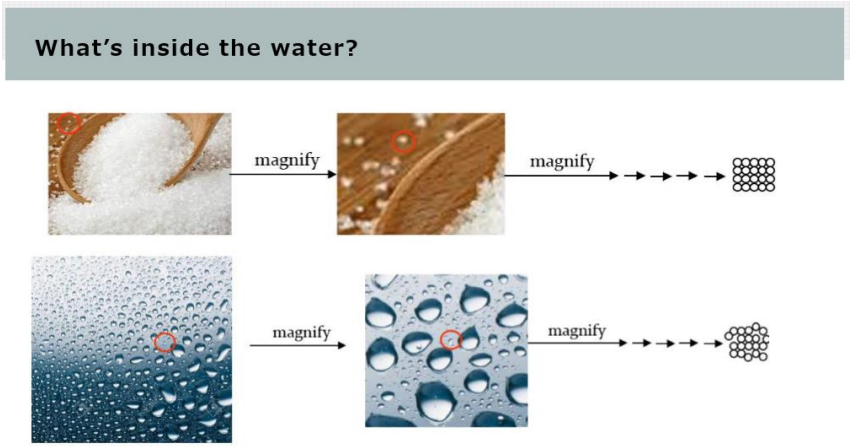
Question:

What would happen to the total volume when 50 ml water is mixed with 50 ml alcohol?

A) more than 100 ml

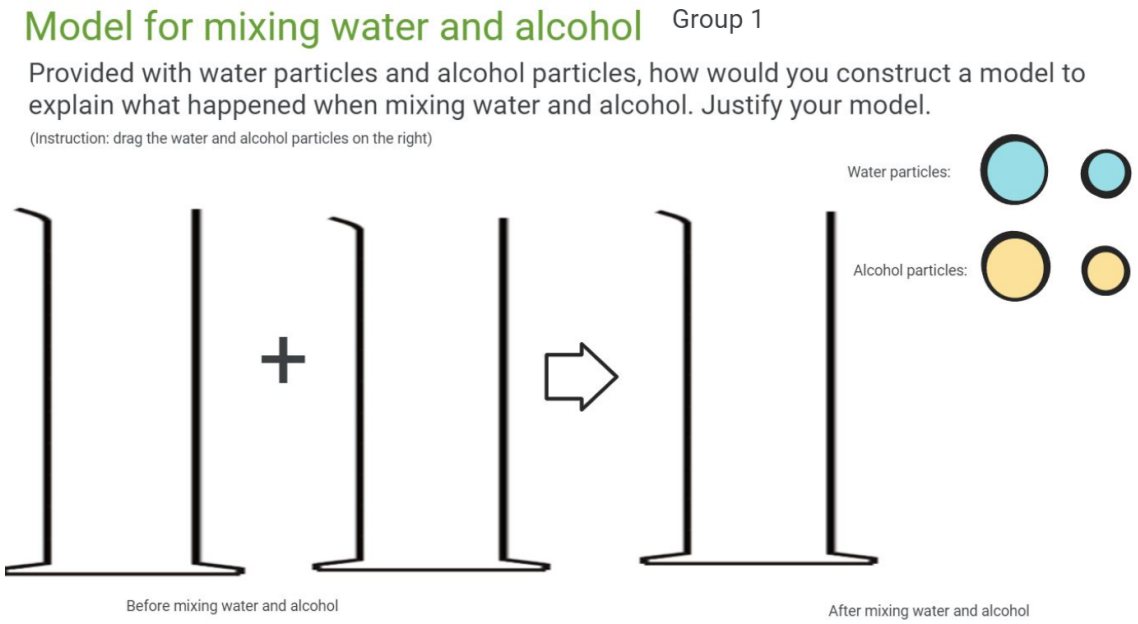
B) equal to 100 ml

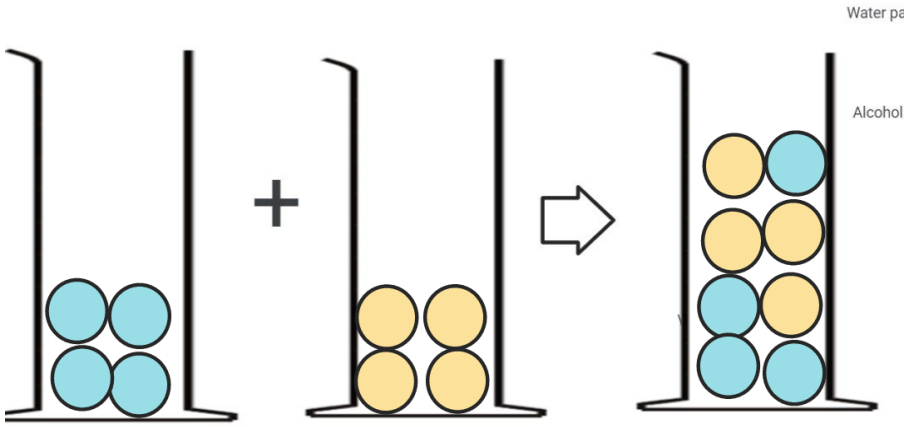
C) less than 100 ml



JAMBOARD FOR STUDENTS TO FREELY EXPRESS UNDER THE FRAMEWORK

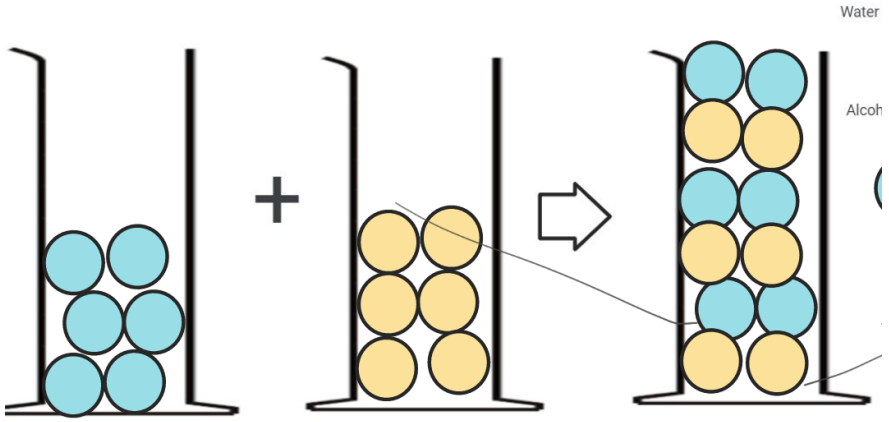
Teachers can create the framework and students can freely move the parts to explain



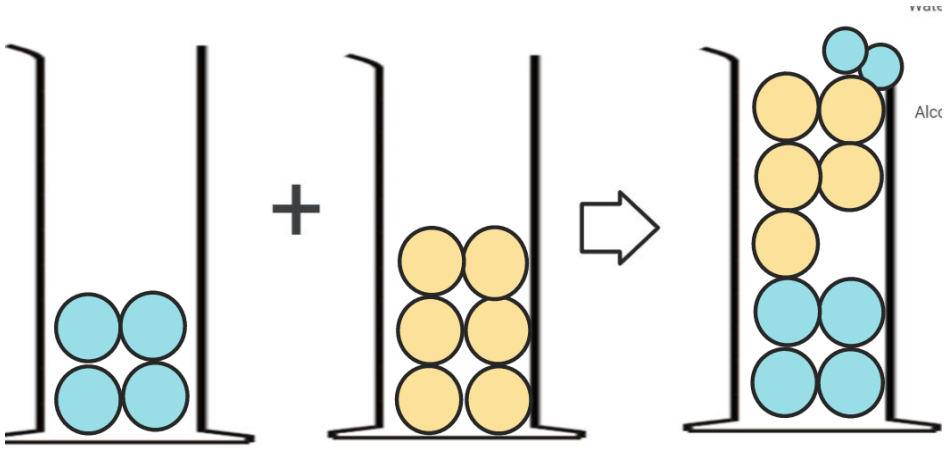


I think the total volume should remain the same.

Why do you think so?



By intuition/ daily life experience of adding more water



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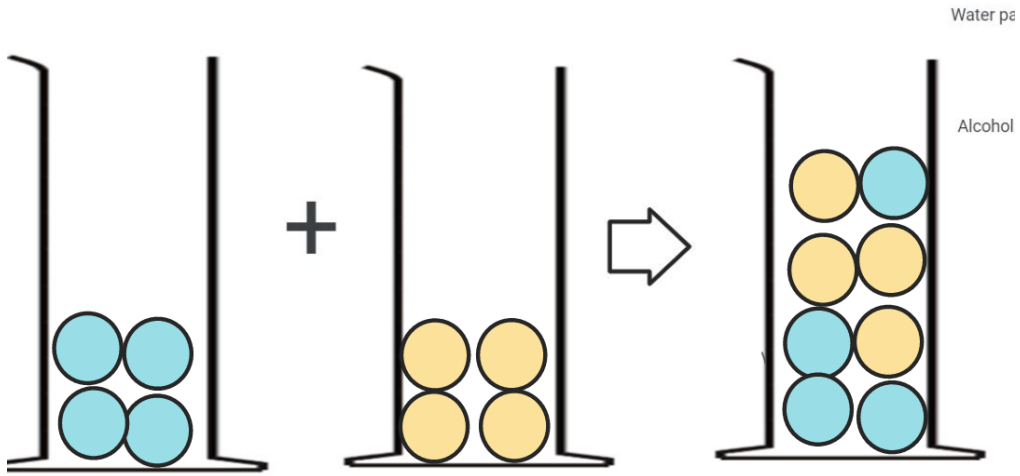
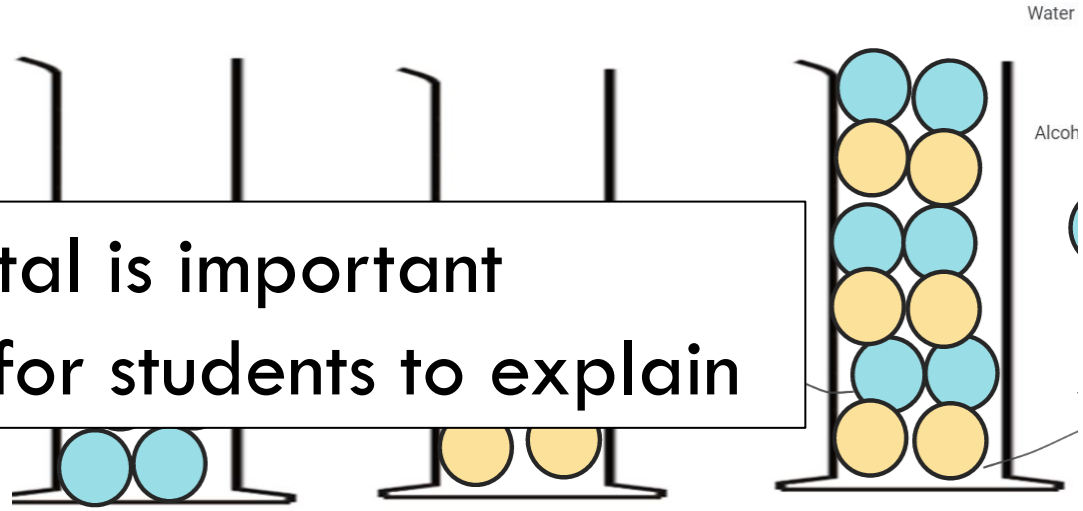
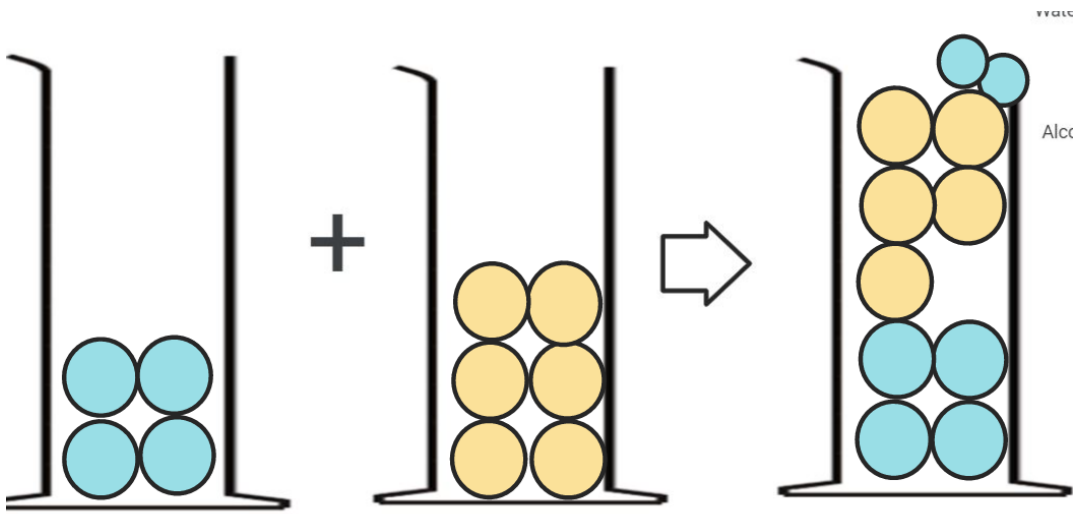




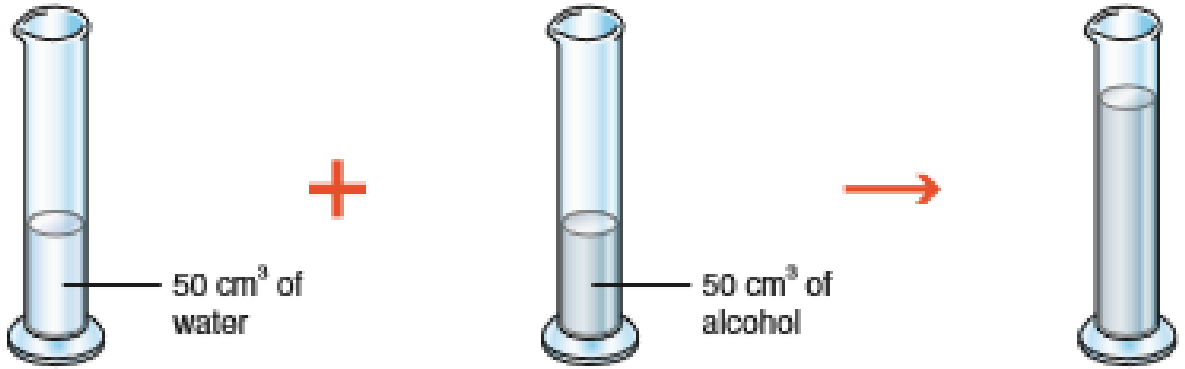
Being non-judgmental is important

This creates a safe space for students to explain



AFTER CREATING THEIR PREDICTIONS WITH EXPLANATIONS… STUDENTS OBSERVE A DEMONSTRATION OF MIXING WATER AND ALCOHOL

3. Now, mix the water and the alcohol.

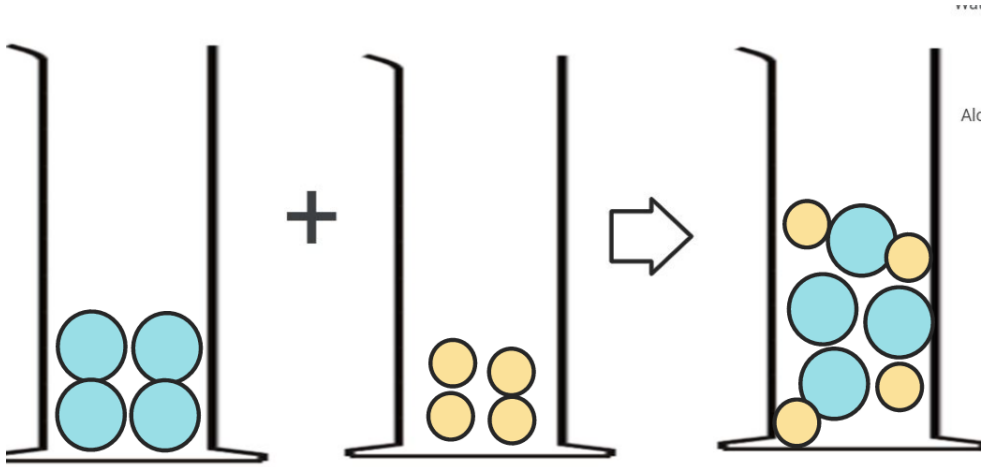


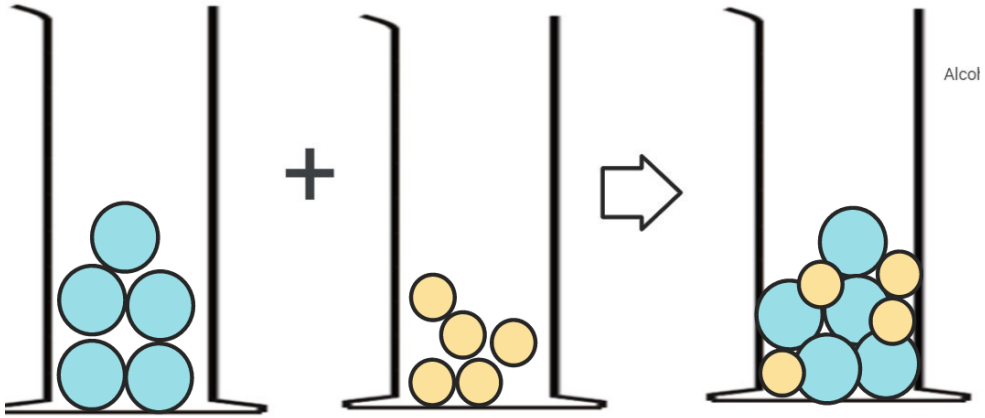
Total volume = ?

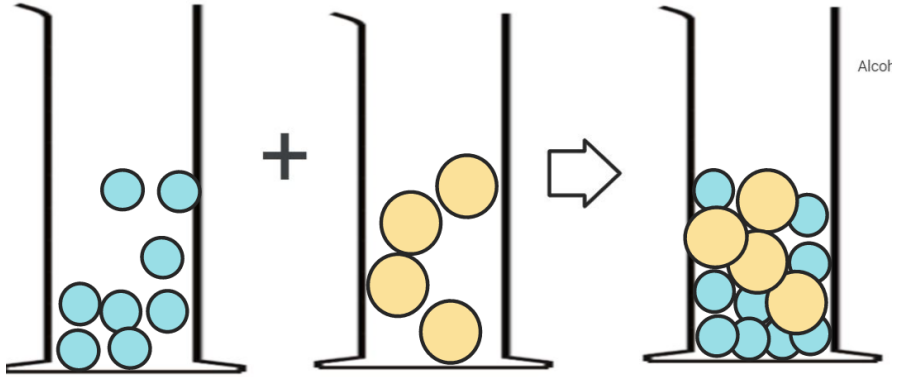
Create a **cognitive dissonance** for conceptual change
Why does the total volume become less?

Asking students to explain it again using the framework with the **delayed scaffolding** (Bean and sago)

JAMBOARD AS A SECOND CHANCE TO MODIFY THE IDEA



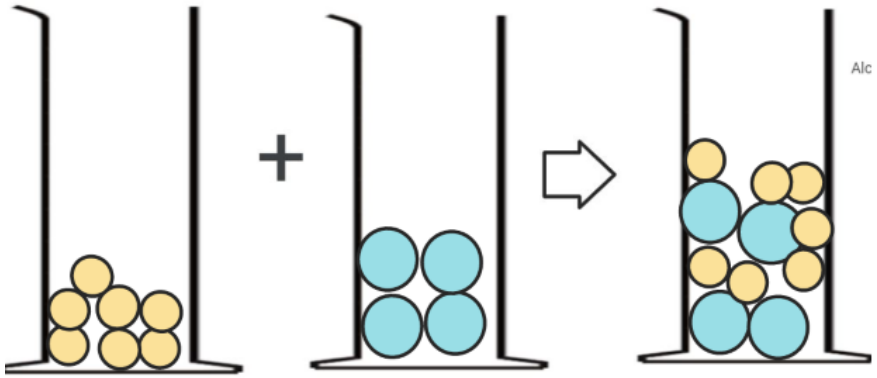


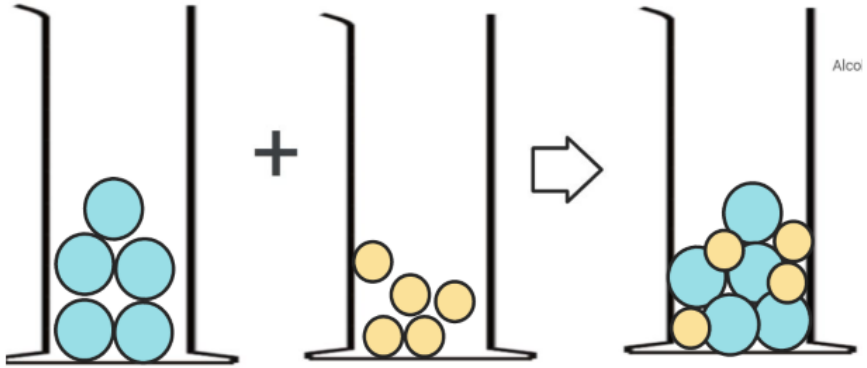


BASED ON WHAT STUDENTS' RESPONSES, WE CAN GIVE THE CORRESPONDING INPUT TO HELP THEM MODIFY THE EXPLANATION

We don’t need to be judgmental immediately, sometimes students just need more input for the modification

Claim, Evidence, Reasoning





Claim: The particle size of water and alcohol are different.

Evidence: Based on the activity of mixing bean and sago, we can see that the total volume after mixing become less. The size of bean is larger than the size of sago. Some sago fit into the space between the bean.

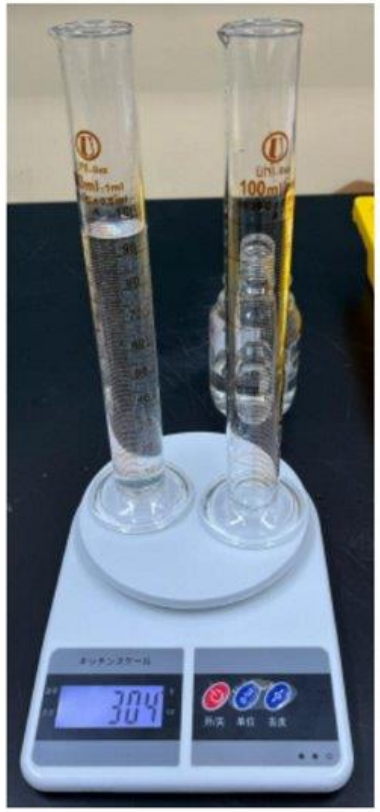
Reasoning: The activity of bean and sago should analogous to the mixing of water and alcohol. The particle size of water and alcohol are different, the water particles may fit into the space between the alcohol particles. Therefore, the total volume after mixing water and alcohol is smaller.

REBUTTAL

A student claimed that the reduction of volume after mixing water and alcohol was due to the evaporation of alcohol.

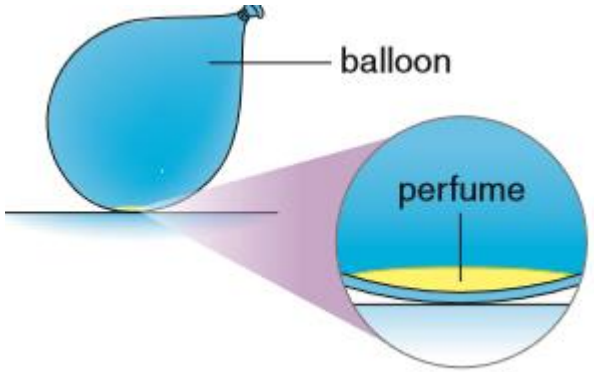
Devise an experiment to test if this claim is correct or not.

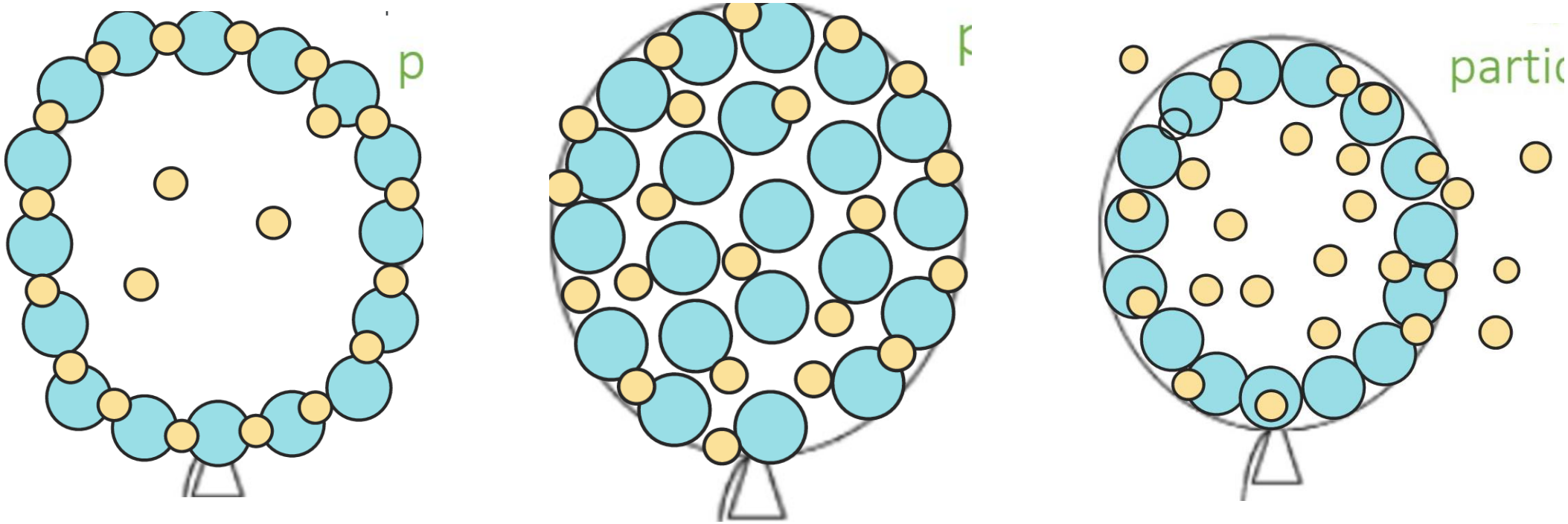
(by measuring the weight before and mixing water and alcohol, the student's claim is supported if the weight after mixing become smaller. If not, then student's claim is not correct.)



TASK 2 – BALLOON AND PERFUME

As consolidation





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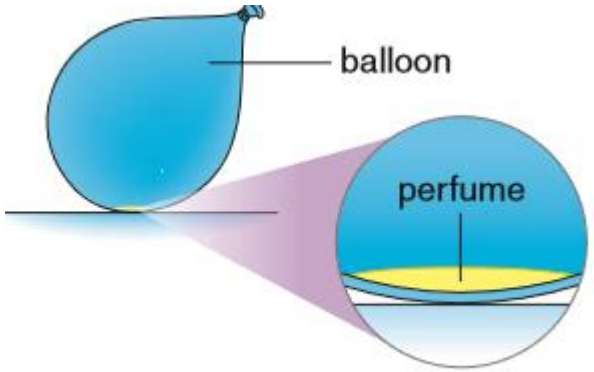
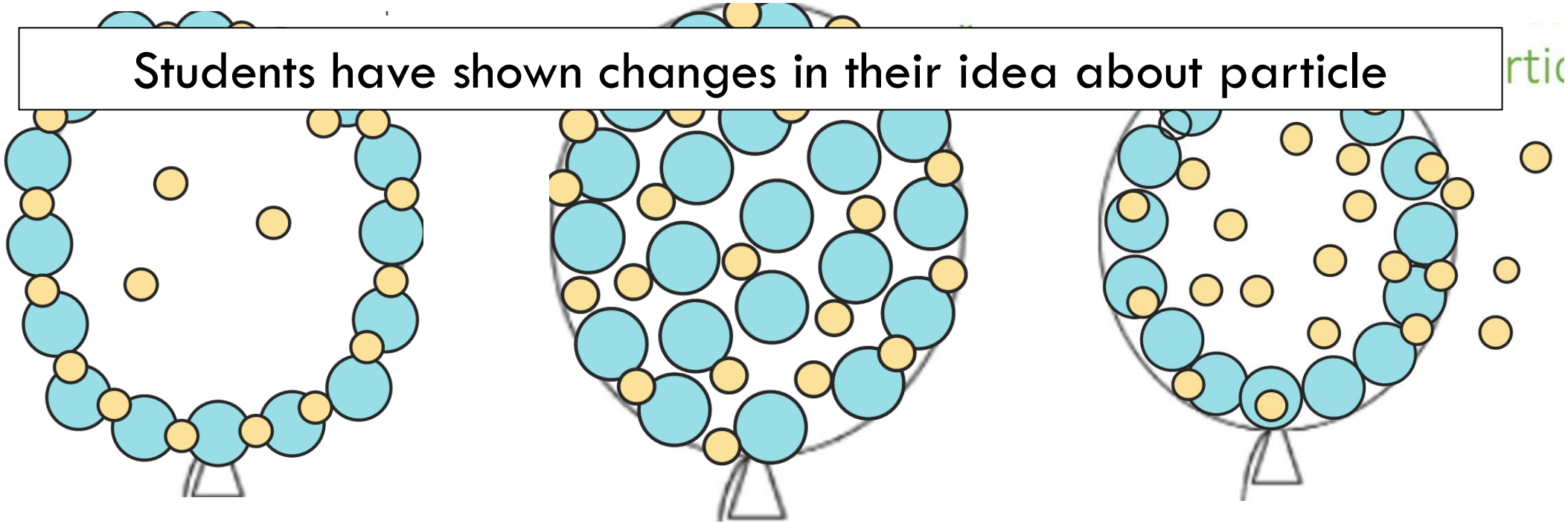


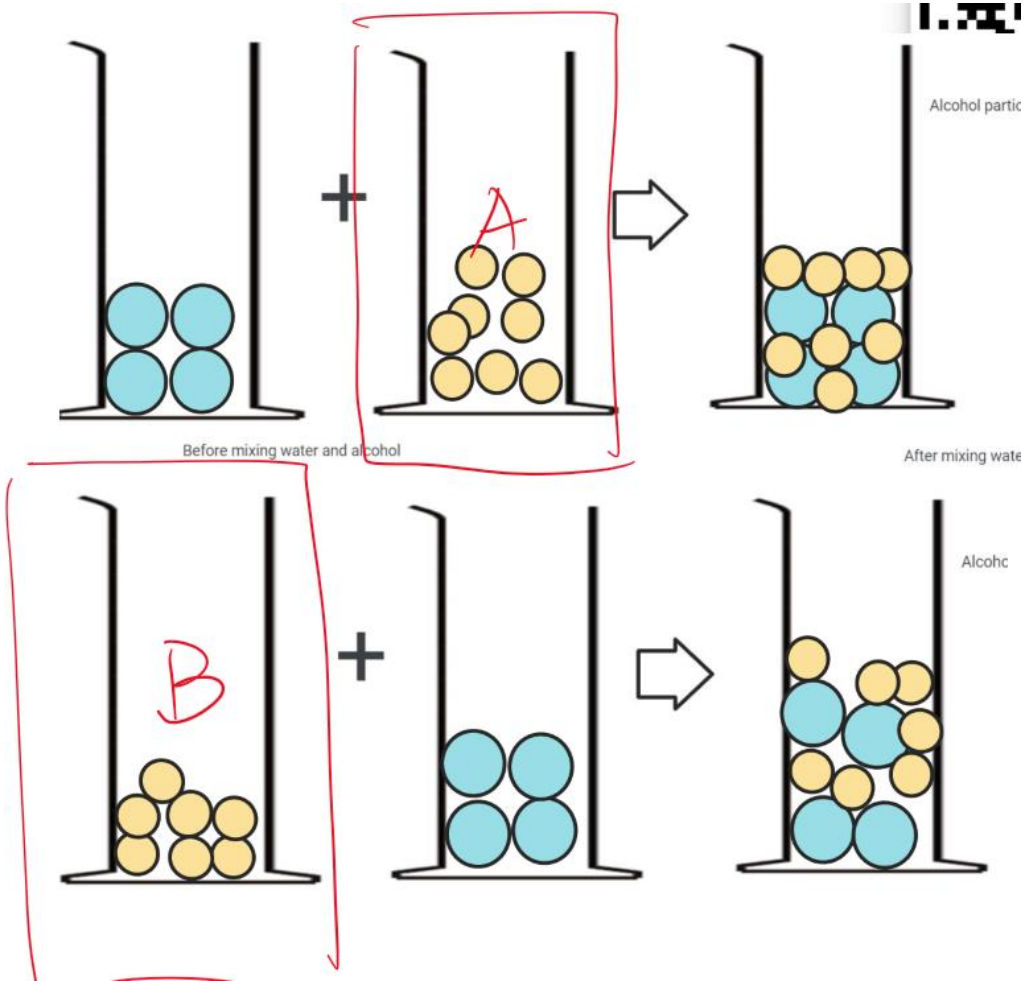
Students have shown changes in their idea about particle



TASK 3 – STATE OF MATTER

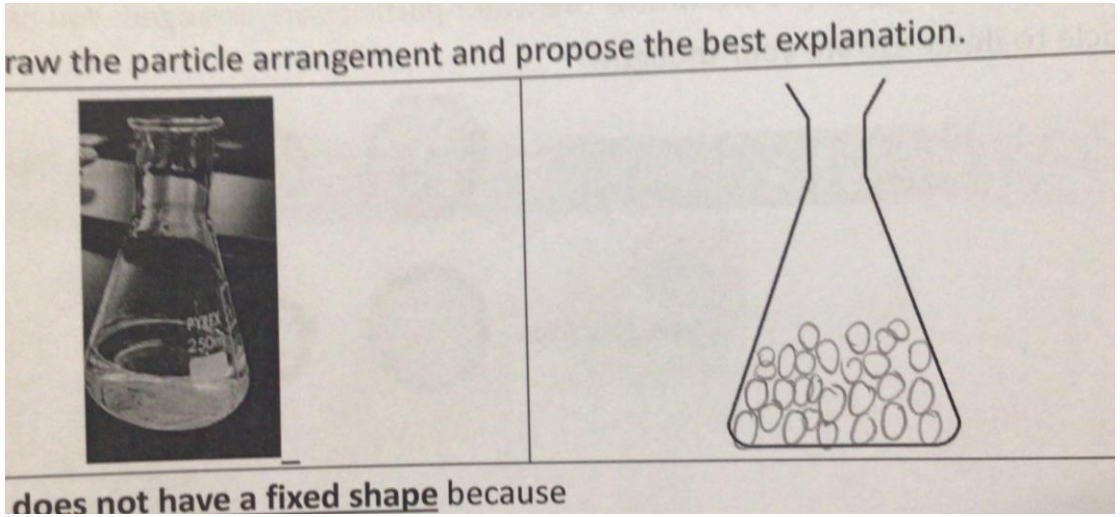
Which diagram better represent the particle arrangement in liquid? A or B? Give your evidence.

Propose the particle arrangement in gas.

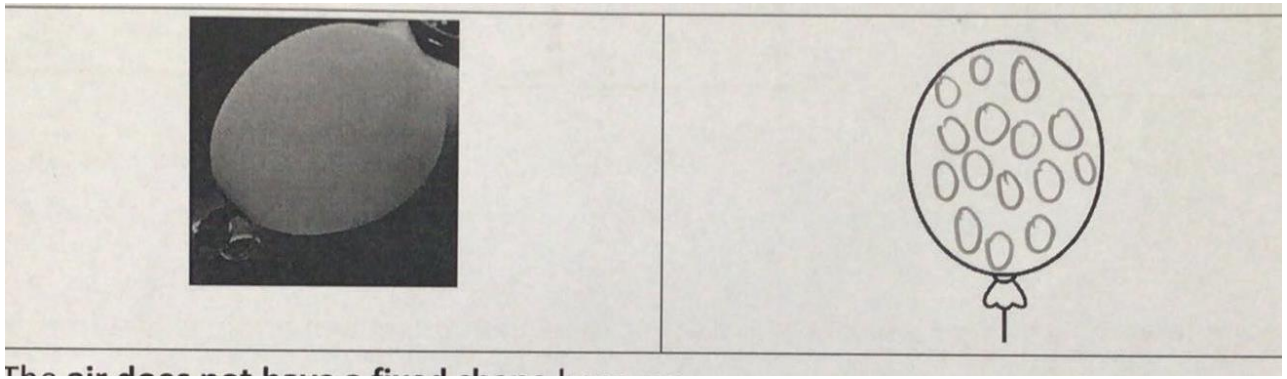


FROM NAÏVE EXPLANATION TO A SCIENTIFIC ONE

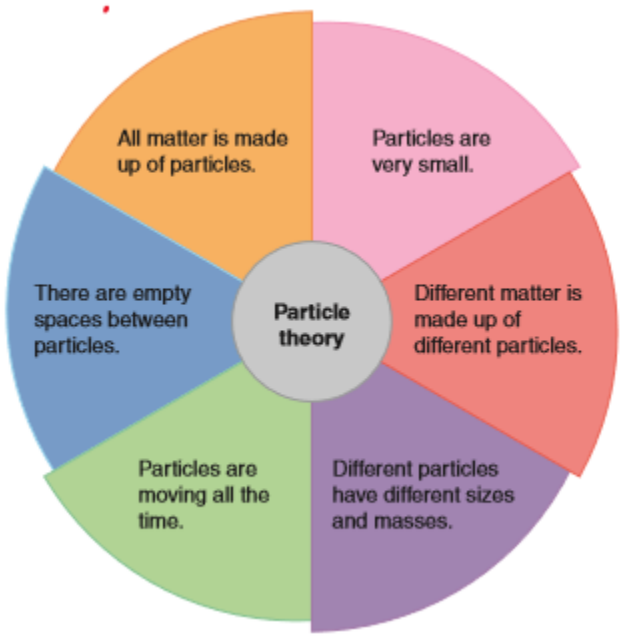
Even without direct teaching, students can somehow generate an idea which is close to the science one.

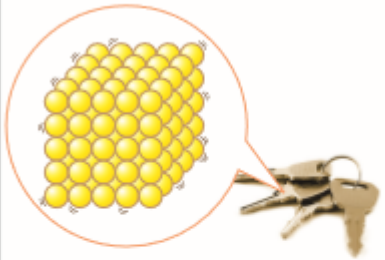
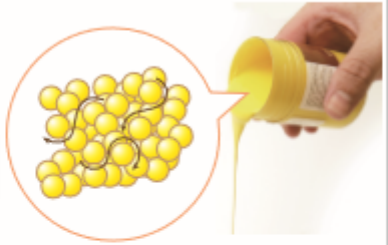
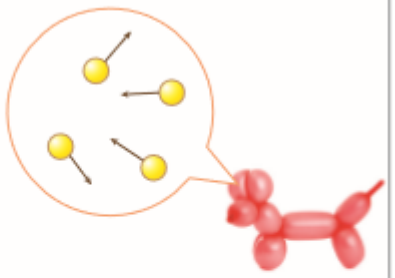


Up to this moment, no teaching about particle theory is done yet.



FINALLY, TEACHING IS DONE AS A CONSOLIDATION



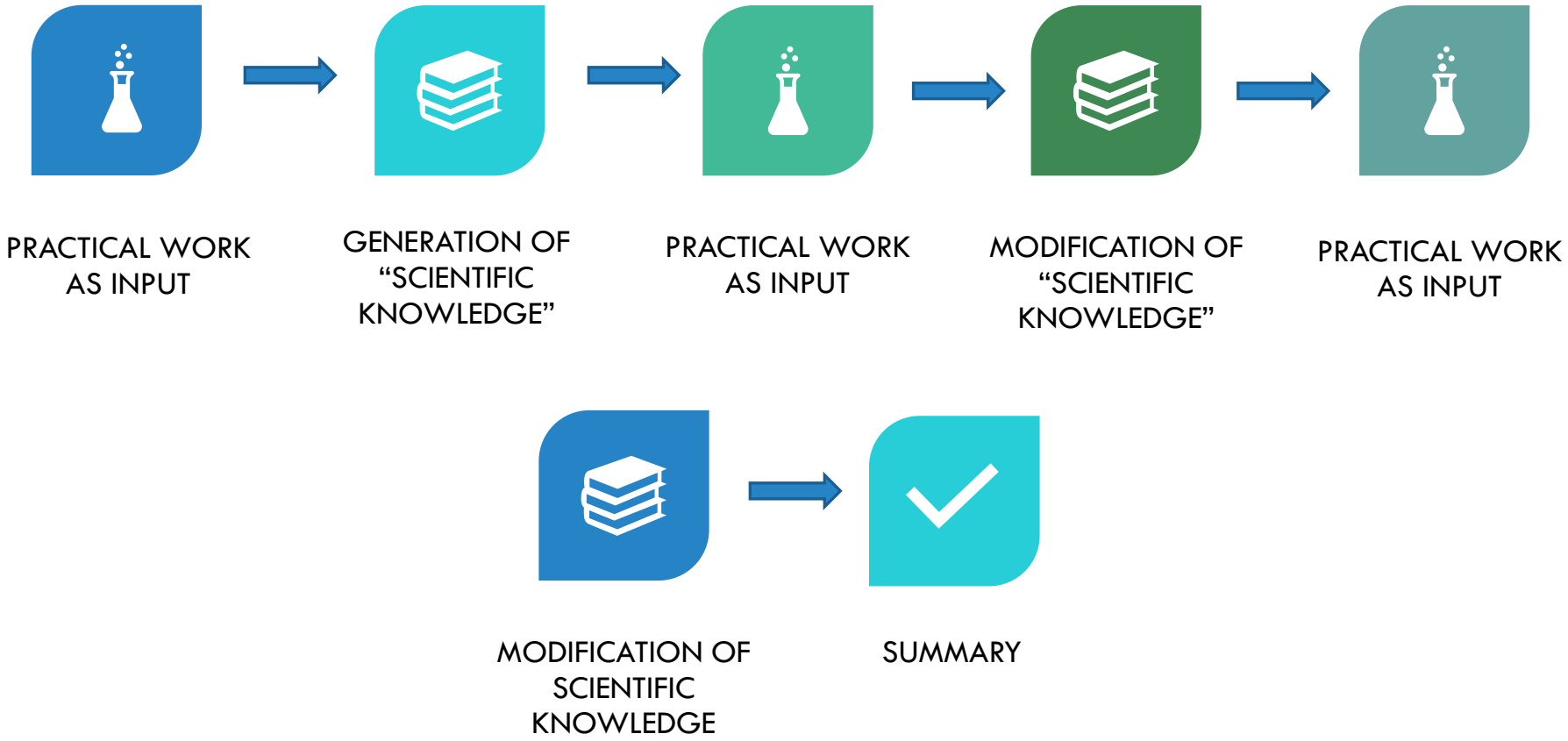
Solid	Liquid	Gas
		
The particles • are close together and arranged regularly. • cannot move from one position to another, but can only vibrate about fixed positions.	The particles • are close together but arranged irregularly. • can move around each other.	The particles • are far apart. • can move freely in all directions.

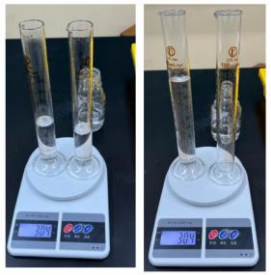
SOME REFLECTION

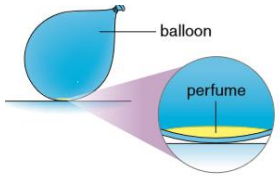
Formative assessment: Keeping on providing chances for students to express their idea can help teachers to elicit students' thinking and act accordingly

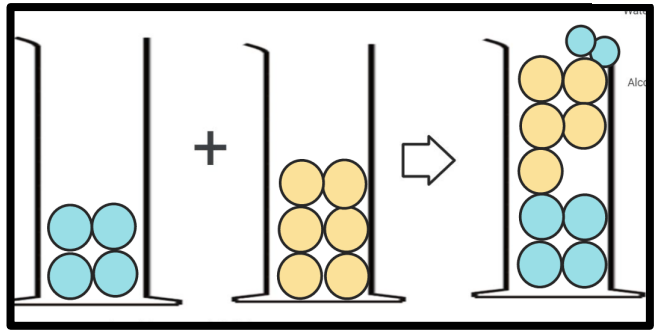
Differentiated instruction: If teachers can **modify our teaching based on students' responds**, students can learn better.

A NEW WAY OF PRACTICE



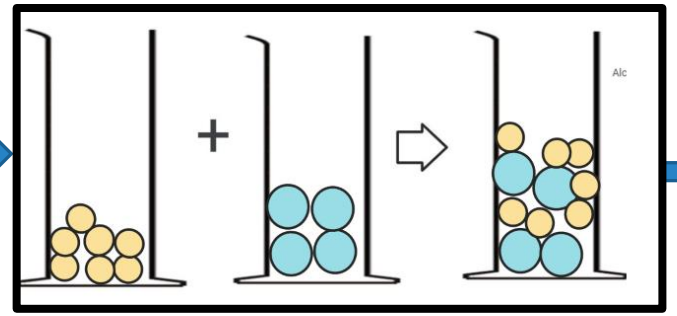






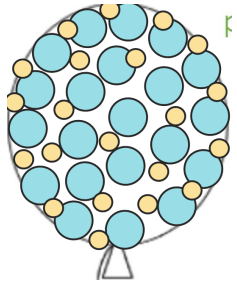
PRACTICAL WORK AS INPUT

GENERATION OF "SCIENTIFIC KNOWLEDGE"

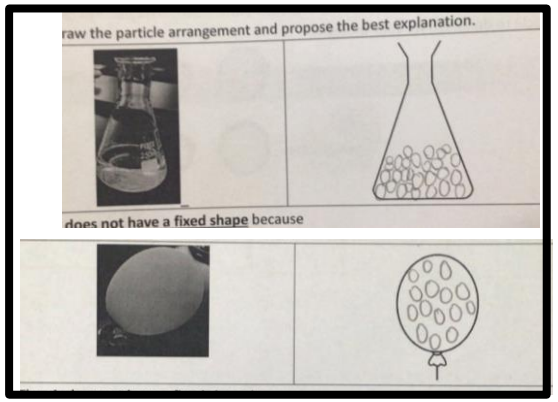


PRACTICAL WORK AS INPUT

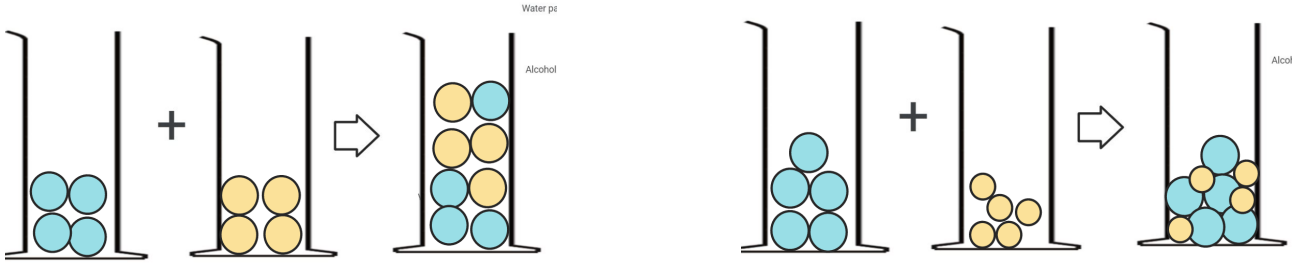
MODIFICATION OF "SCIENTIFIC KNOWLEDGE"

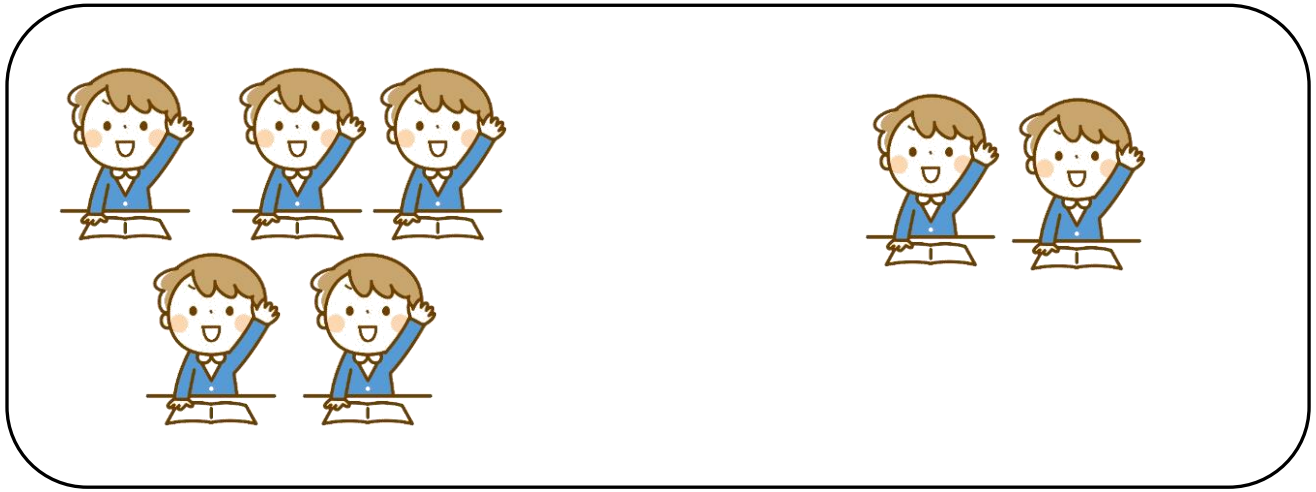


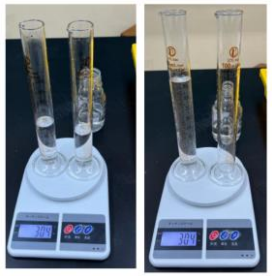
PRACTICAL WORK AS INPUT



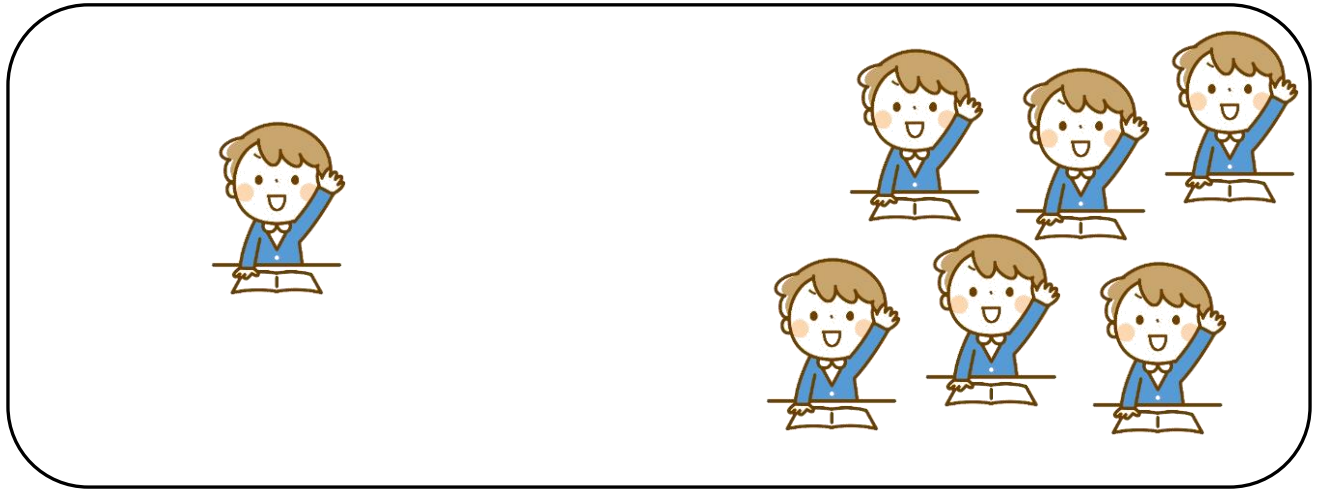
SUMMARY

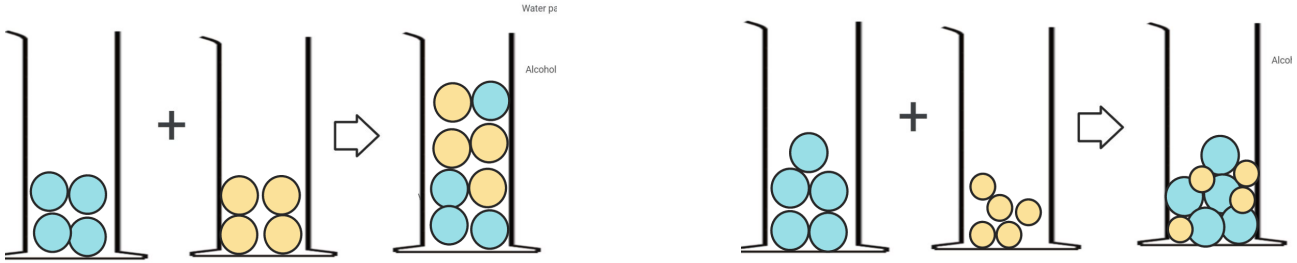






Input given according to their response





Students can make their own claim (model) based on evidence

Input given according to their response

EVENTUALLY, STUDENTS WILL MOVE FROM NAÏVE IDEA TO A RELATIVELY SCIENTIFIC ONE

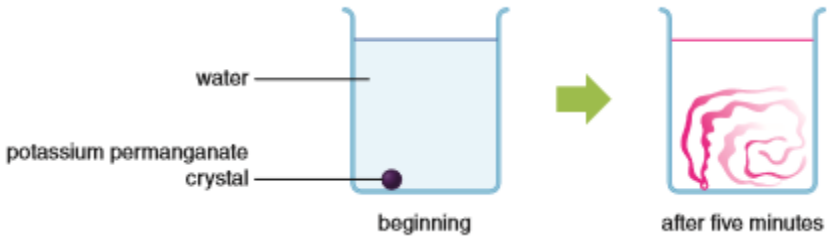
JUST A CHANGE OF THE TEACHING SEQUENCE CAN MAKE THINGS DIFFERENT

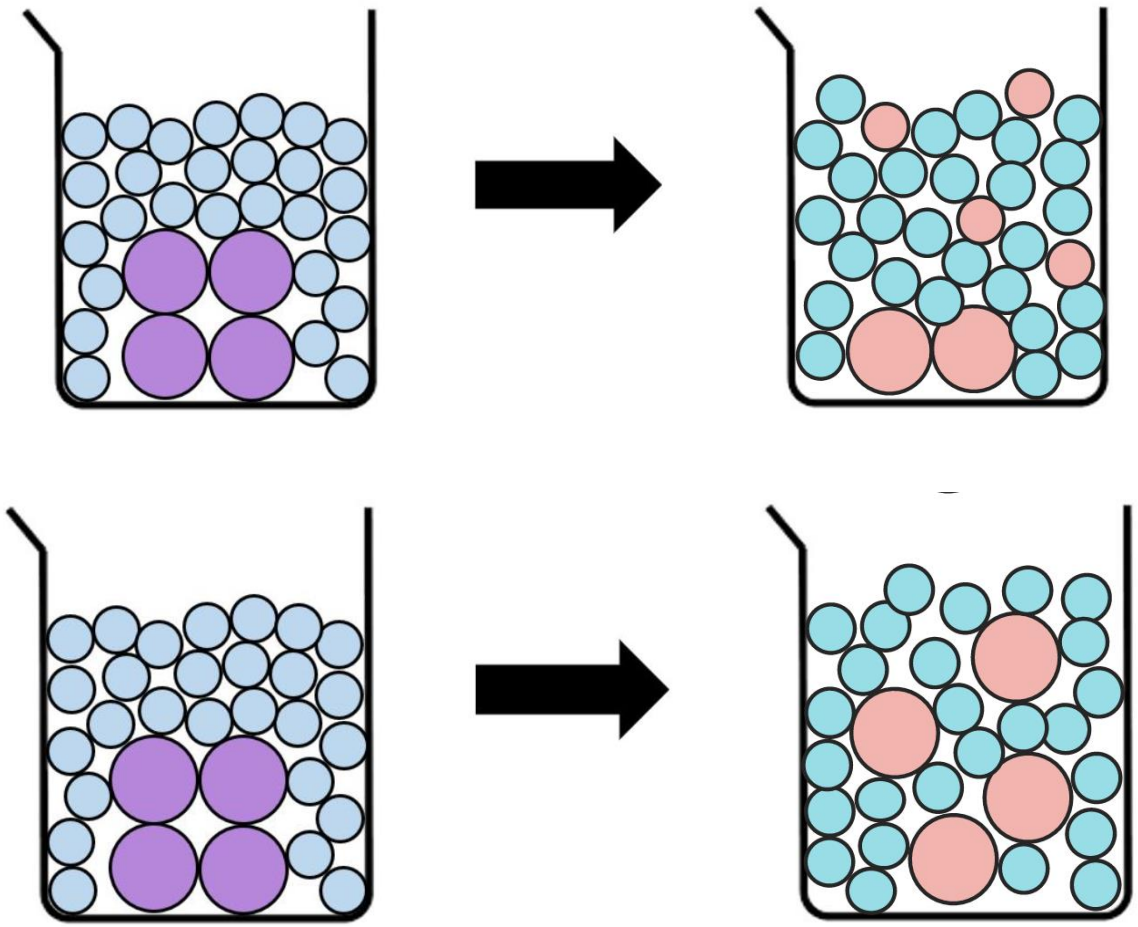
No change in practical work

No change of teaching time required

Just a change of our orientation

TASK 4 - DISSOLVING





AND THE STORY CONTINUES

Q&A

REFERENCES

Cheng, M. M. W. (2016). Strategies for introducing the particle view of matters: cognitive conflicts, practical activities, multiple representations and assessment for learning (A0543). In *International Conference of East-Asian Association for Science Education, EASE 2016*. East-Asian Association for Science Education.