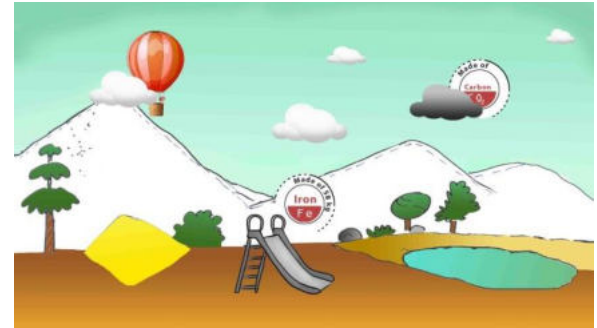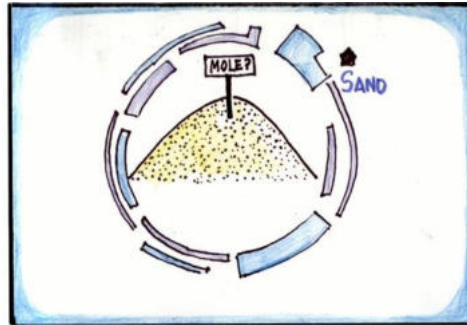# A learning aid for chemistry topic :
MOLE CONCEPT

PROJECT 3
GUIDE : Prof. Anirudha Joshi
Labeeba K | 146330008

Previous Exploration

- **Mole Scope** – Mole visualizer

- **How big is a mole** – Sand video

Feedback from jury

- Identify specific hard spots and address them

- The idea doesn't explain why mole is taught and its application in stoichiometry.

- Tackling the misconceptions in students minds

- Learning mole from macro to micro world vs atoms to mole

- Confusion while using hypothetical world – mole world

- Lack of theoretical backing

Further Study

Hard Spots

- Students do not know why it is taught.

- Lack of important prerequisites – Atomic mass, Atomicity and RAM

- Misconceptions

- Lack of link between Mole , atomic model and other parameters like mass, volume

- Language ambiguity

- Lack of imagining small size of atoms and magnitude of Avogadro number

Secondary research

- **Jim Minstrell's** work on misconceptions

- **Diagnoser Project**

    Learning Goals

    Facet Cluster

    Elicitation Question

    Developmental Lesson

    Diagnoser Question Sets

    Prescriptive Activities

- Example : **Atom**

Elicitation questions

A list of questions were identified around the problems with mole and given to children to identify the misconceptions/facet clusters.

Users : four 10th standard students (already learned mole in 9th std) from KV school

The Result

ELICITATION QUESTIONS

These questions are to be asked in class once you realise that students are not getting the concepts clearly. These questions are made based on the each facet cluster and measures what are the preconceptions and misconceptions of students on the subject.

You can take a printout of the questions and distribute in class.

1. Compare the masses of these atoms.

Hydrogen atom   Oxygen atom   Sodium atom   Uranium atom

Misconceptions

- Atoms are all the same and have similar size and mass

- Mole is a term used only for measuring/counting molecules

- 'Amount of Substance' – means mass, hence mole is more related to mass

- Atomic mass and molar mass have the same value. They might be the same

- 1 mole of various substances look very different and differs in mass, volume and quantity except gases. Then how do they have same amount of substance?

- In a balanced chemical reaction, assuming that the coefficient will work for masses of the substances also.

   For example, for the reaction $H_2 + Cl_2 = 2HCl$, assuming that 1g of H_2 will react with 1g of Cl_2 to give 2 grams of HCl.

Language Ambiguty

- **Mole of WHAT ?**

    Mole of atoms, molecules, ions, electrons

    Example : Mole of atoms of H_2 and Mole of molecules of H_2

- **Amount of substance** - Mass/ Volume/ Number?

- **Molar mass** – Mass of substance in a mole – **g/mol**

Project brief

Design an interactive tool that aids students in learning mole concept through activities

- to reduce misconceptions
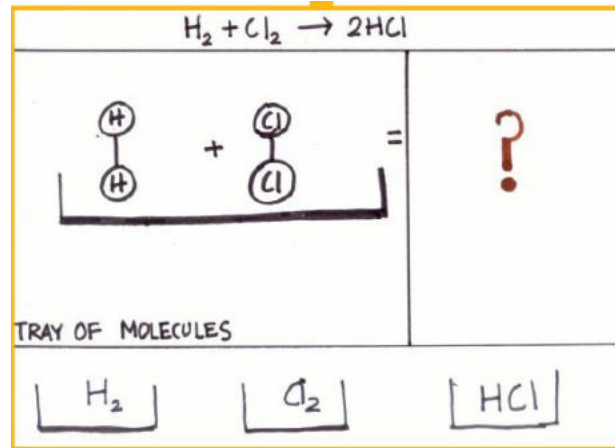
- to practice and learn the basics

Ideations

1.Students do not know why it is taught.

Activity scenario

ACTIVITY

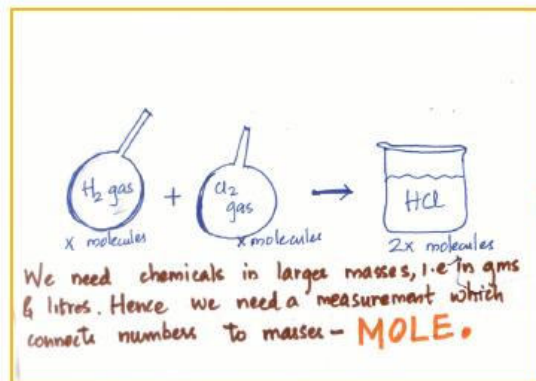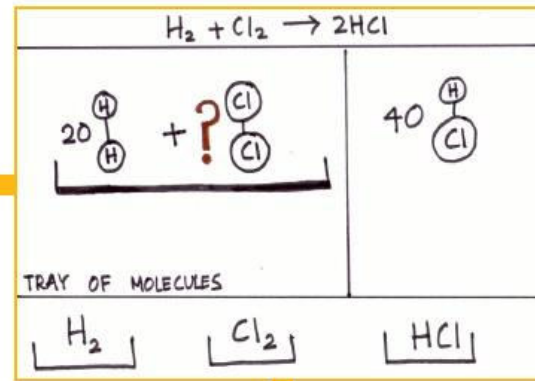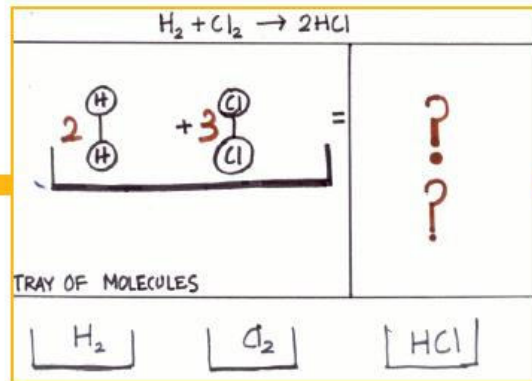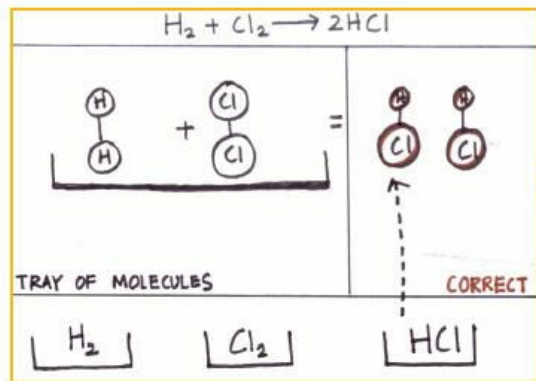Assume you are in an industry that makes HCl for manufacturing PVC. You are in a lab and you are asked to make HCl from molecules of H_2 and Cl_2. What is your experience? Explore

$H_2 + Cl_2 \rightarrow 2HCl$

TRAY OF MOLECULES

H_2 Cl_2 HCl

Panel 1 (top-left):
$H_2 + Cl_2 \longrightarrow 2HCl$

H–H + Cl–Cl = H–Cl H–Cl

TRAY OF MOLECULES   CORRECT

| H_2 | | Cl_2 | | HCl |

Panel 2 (top-middle):
$H_2 + Cl_2 \longrightarrow 2HCl$

2 H–H + 3 Cl–Cl = ? ?

TRAY OF MOLECULES

| H_2 | | Cl_2 | | HCl |

Panel 3 (top-right):
$H_2 + Cl_2 \longrightarrow 2HCl$

20 H–H + ? Cl–Cl   40 H–Cl

TRAY OF MOLECULES

| H_2 | | Cl_2 | | HCl |

Panel 4 (bottom-left):
H_2 gas + Cl_2 gas → HCl

x molecules   x molecules   2x molecules

We need chemicals in larger masses, i.e in gms & litres. Hence we need a measurement which connects numbers to masses — **MOLE.**

Panel 5 (bottom-middle):
H–H   Cl–Cl

Inference
But atoms and molecules are very small. It is impossible to count extremely minute particles and make them react in this manner in industries and labs

Panel 6 (bottom-right):
INFERENCE

If equal Number of H_2 and Cl_2 molecules combine, then we get double the number of HCl molecules, without residue. Otherwise we will have wastage of chemicals.

Ideations

1.Lack of prerequisites – Atomic mass, Relative atomic mass
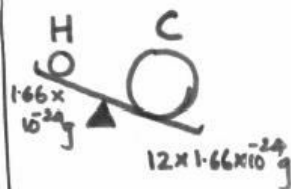
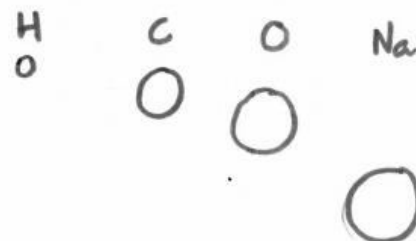**Solution scenario**

Panel 1 (Inference):
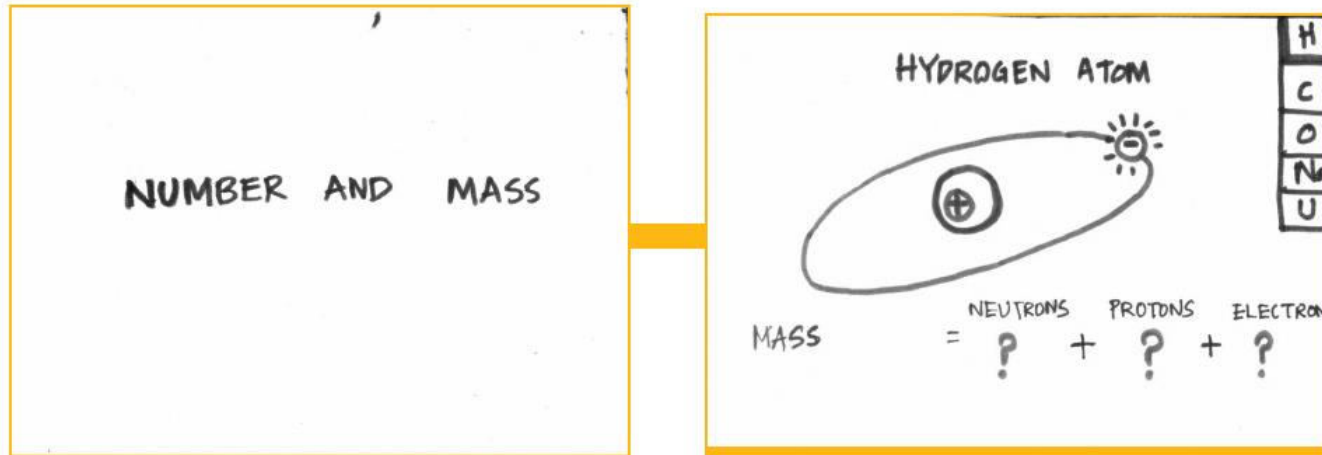
Inference:

The actual mass of atoms are very small.
Hence, for the purpose of calculation atomic mass is taken relative to each other considering

$1.66 \times 10^{-24} g = 1u$

Panel 2:

H   C

$1.66 \times 10^{-24} g$ $12 \times 1.66 \times 10^{-24} g$

RAM   1   :   12

Panel 3:

H   C   O   Na

	H O	C	O	Na
RAM	1	12	16	23
ATOMIC MASS	1u	?	?	?

Panel 4:

When 6.023×10^{23} atoms were taken for each

H   C   O   Na

	H	C	O	Na
RAM	1	12	16	23
MASS	?	12g	?	?

Panel 5:

If 10 atoms of each are taken

H   C   O   Na

RAM   1   :   12   :   ?   ?

Panel 6:

If 2 atoms of each are taken

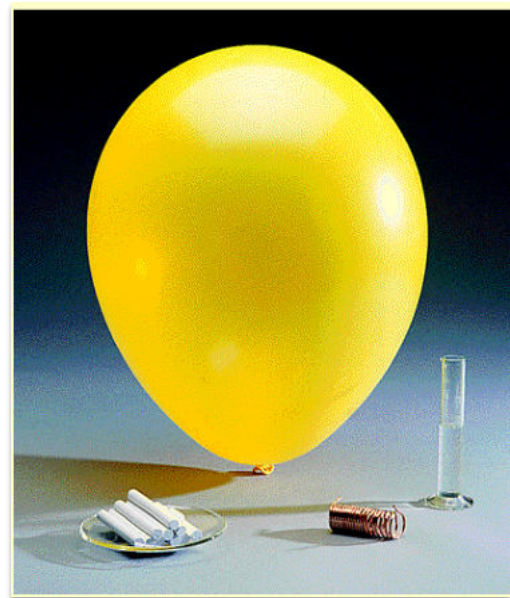Relative Mass   1   :   ?   :   ?   :   ?

Ideations

Mole and misconceptions

Solutions

1.Misconception : As one mole of various substances look very different in quantity, how can the 'amount of substance' be same. Assumption that number of particles also might be different.

Mole and misconceptions

Solutions

2. Misconception : Moles are only for molecules

3. Using real world questions to ponder mole.

a. You are thirsty after work. You bought 1 litre mineral water for 18 Rs. How much did one molecule of mineral water cost you ?

b. If your bike was made totally of Iron, How much moles of iron would have been used to make your bike?

16

Final concept- Molegyan

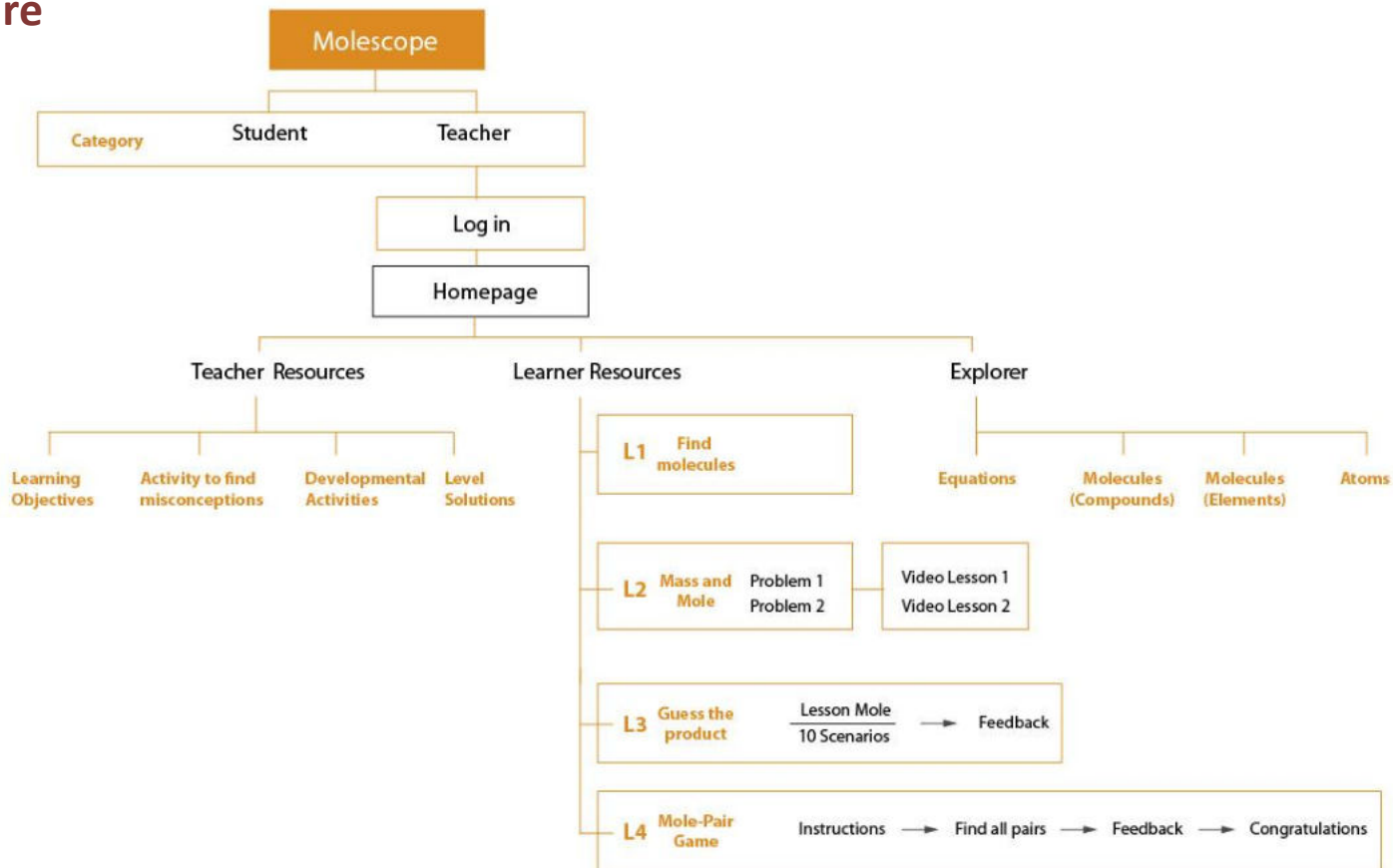The learner and Explorer

Problem solving method

Activity levels
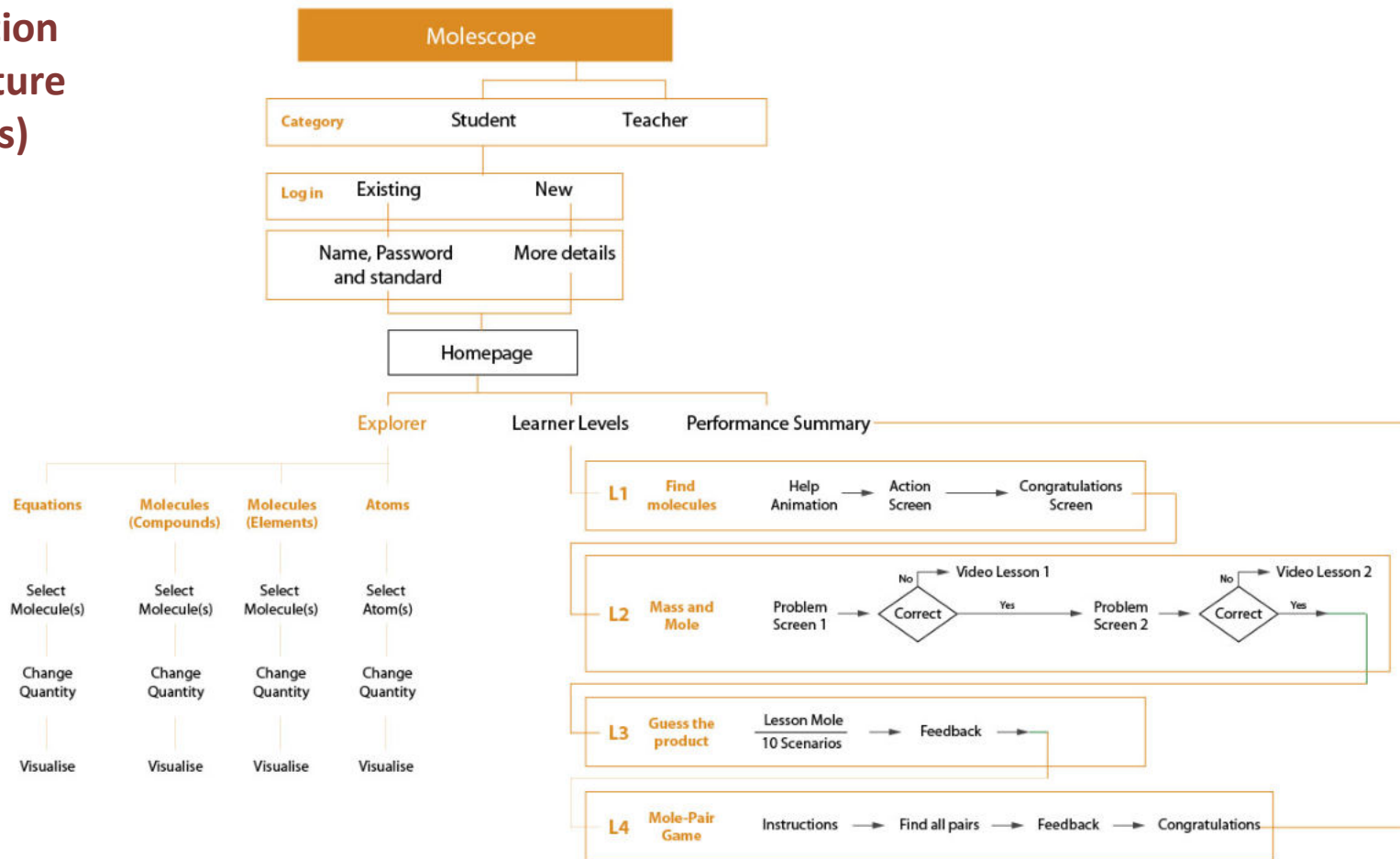
Learning prerequisites

Teacher Aid

mole gyan
learn . Play . Enjoy

Information Architecture (Teachers)

Information Architecture (Students)

Initial Prototype

Testing.

Testing Protocol

Teacher

- 1 highschool teacher– Bharghav, KV School

- Give a walkthrough of the Teacher section and record insights

- Use and analyze learner levels with learning outcomes and usability

Student

- 2 students from class 10th standard,1 student from 12 th, KV school who have already learned Mole concept in 9th

- Introduction of the tool and a small 1 min discussion on mole

- Testing against **learning outcomes** in level 1- 4

Insights from teacher

- 'Teacher tab is useful in remedial classes for students who cannot do the problems'

Level 1 (Find molecules) : Interesting activity to build interest

Rather than focusing on smallness of atoms in the note, You could say about mono, dia,

and poly atomic elements.

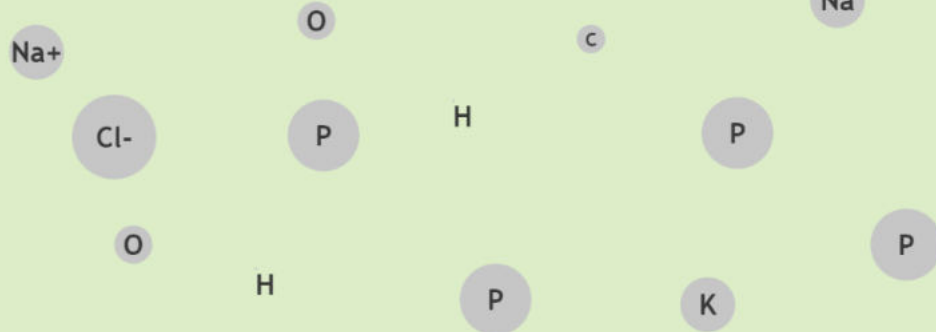**Size of atoms** - Creating misconceptions ?

Level 2 (Mass and Mole) : Activity 1 effective in learning molecular mass

Activity 2 : **Relative mass without lesson** might confuse children

Activity 3-5 : Students might not get your intended flow

L mole gyan

Na

O

c

Na+

Cl-

P

H

P

O

P

H

P

K

FIND MOLECULES

TASK : Find and make molecules.

ATOMS ARE VERY VERY SMALL
IN SIZE AND MASS THAT IT
CAN'T BE VIEWED WITH EYES
OR A MICROSCOPE

Level 4 : Interesting only for higher grade students

    Difficulty level very high – comparing particles in mole of atoms, molecules and ions

    Go for level based pair game using less calculation

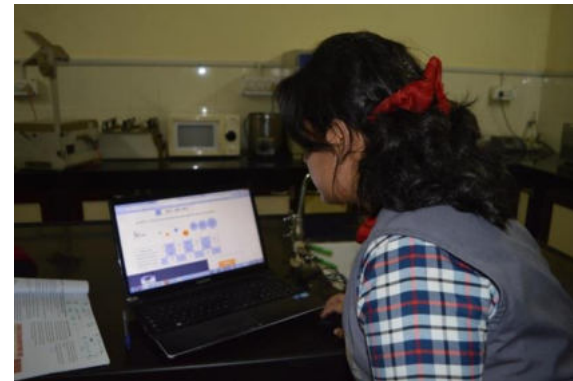**Usage** : Teacher was vey weak in using the product and understanding the flow compared to students.

54g H_2O Molecules	2g H Atoms	4mol H_2 Molecules	108g Al Atoms
6×10^{24} Zn Atoms	98g H_2SO_4 Molecules	6×10^{25} O Atoms	224l N_2 Molecules
100mol Cl_2 Molecules	476g U Atoms	67.2l CH_4 Molecules	5mol Al Atoms
6×10^{23} Na^+ Ions	5mol $CuSO_4$ Molecules	31g Cu Atoms	11.2l CO_2 Molecules

Testing - Students

Insights from students

- **Limitation** : Mine or teachers presence tend to be stressful and reduced exploration

  Confusion from Level 2 due to abrupt starting of activity

- Students avoided the additional videos altogether.

- Notes and feedbacks given lower importance compared to actions

- 'Forgot mole. We don't have to learn it in 10th' – Common response

- '**Conserving number of molecules**' in Level 3 ?

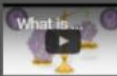- Lack of knowledge of molar volume and 22.4l

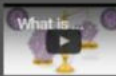| LEVELS	Learning outcomes	Student 1 (Easha-10)	Student 2 (chiya-10)	Student 3 (Abhishek-12)
LEVEL 1 (Find molecules)	What are monoatomic, diatomic and polyatomic molecules? Atoms are all of different type.	Score : 5/7 Couldn't identify NaCl from ions.	Score : 3/7 Could identify all mono atomic molecules	Score 7/7
LEVEL 2 (Mass and Mole)	Act 1: Atomic and molecular masses in elements. Act 2 : Masses of atoms are relative. Act 3- 5 : 1 mole of all elements contain 6.023×10^{23} particles. How is mole related to atomic mass?.	Act 3-5 difficult. Couldnot proceed	Act 3-5 difficult. Couldnot proceed.	All answered well, and had clear understanding on the basic of mole
LEVEL 3 (Guess the product)	How mole is used in stoichiometry? Ability to link mass , mole and volume	Confusion on balancing equation itself	Confusion on balancing equation itself	Too simple
LEVEL 4 (Mole pair game)	Testing the learning of mole	game : 1/8	game : 0/8	game : 4/8 (time = 5 min)

ACTIVITY 3 : If you take 100atoms of these elements, what will be the total mass and relative atomic mass

	H	C	O	Na	Cl	P
ATOMIC MASS	1u	12u	16u	23u	35u	30u
MASS OF 100 ATOMS	?	1200u	?	?	?	?
RELATIVE MASS	?	12	?	?	?	?

Confusion in Level 2

Iteration – Changes made

- Level 2 – 'Introducing mole' as it was a prerequisite for further activities

- Reducing difficulty level of Level 4

Changes

Introducing mole through a video after the Activity 2 (relative atomic mass)

Video should recall what is avogadro number and concept of mass and mole

Changing the mole problem representation – Level 2 activities

Iteration - Prototype

Final testing

Teacher (Deepthi (Takes Chemistry in 10th standard in GHSS Koduvally))

- For students with very **low knowledge on basics** , there will still be difficulty

- For others, it is better to give it to them **without teacher assistance**.

- Misconceptions given for teacher references are valid among her students

- **Level 2 should be upgraded** for more elements

- Can you add **relative molecular mass** and molecules of compounds in level 2?

- **Giving atomic mass** – not required as students are supposed to memorize them

- Give more variety in Level 3 – stoichiometry activity.

- According to her, Only 20% students in her class can do it without learning mole, but the rest 80% - as activity after teaching mole.

Final testing

Student

- 3 students from class 10th who have not learnt mole concept yet.

- English medium students from GHSS Koduvally

- Assistance was given at the beginning of each level to explain the intend of level.

- Testing on learning outcome : Performance

LEVELS		Student 1 Aysha Farsana	Student 2 Fidha	Student 3 Silmia
LEVEL 1 (Find molecules)		O_2, NaCl, Na, K, P_4 Score 5/7	Score 6/7 All monoatomic elements done, ions not done	Score 7/7
LEVEL 2 (Mass and Mole)	Activity 1	Score 6/6	Forgot that certain atoms are diatomic	Done – all
	Avtivity2	6/6	6/6	Done - all
	Video and Activity2 & 3	**Activity2** : Molecular mass should be given (Cu, S – difficult) **Activity 3** : 22.4l not understandable	Same issue **Activity 3** : NaCl - confusion	Less attention on video **Act.2/3**- not done
LEVEL 3 (Guess product)		**1 questionCo_2- 3** 44g - difficult	**1st question doubt-?** Not thorough on equations	Not done
LEVEL 4 (Mole pair game)		I game :1/8 II game : **3/3**	I game :0/8 II game : **3/3**	**Concept not understood**

TASK : Find the mass of one mole of molecules of elements.

START

GUESS THE PRODUCT

0/10

$$C \quad + \quad O_2 \quad = \quad CO_2$$

1 molecule   1 molecule   ? molecule/s

Design changes from testing

- Sets of levels should be made for the LEVEL 4 : Mole pair game

- If possible feedback for actions can be given more importance in design and it can become hints for the questions

- Provide atomic masses of elements wherever required

Conclusion

- Product was successful wrt to learning outcomes, design for misconceptions can improve.

- A mixture of video learning and activity (tangible or digital) best for mole concept.

- The product should be in context to students level of knowledge.

- As it is a nested concept, learning prerequisites a must.

- Future scope : Prototype can be developed to include more students to self learn

- Both design explorations can be combined, mole Scope being the explorer.

Thank you and Feedback