ATOMATIC

An Inclusive Chemistry Learning Aid for Visually Challenged Children

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Guide: Prof. Girish Dalvi

Motivation

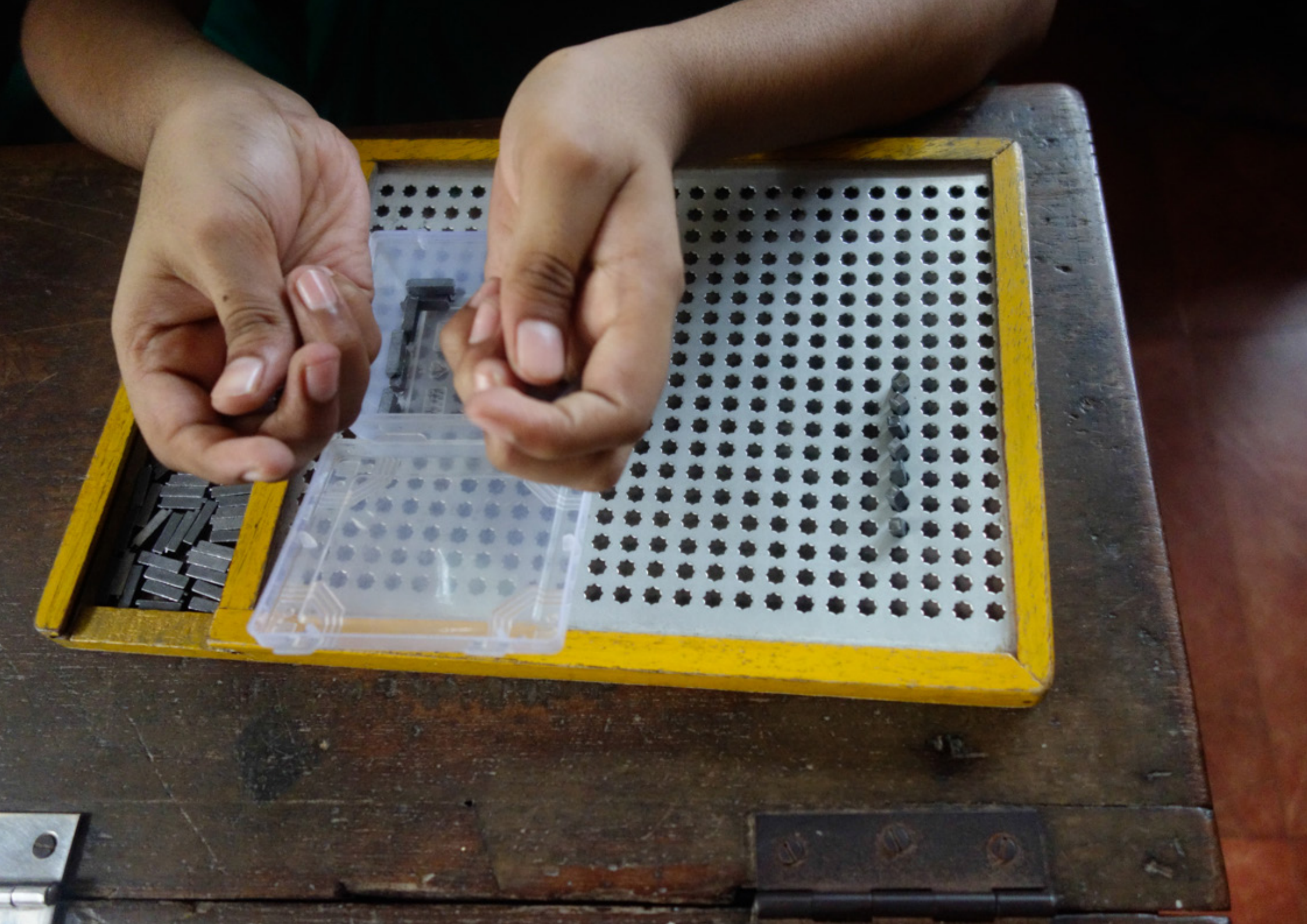
- Explore non-visual and tangible interfaces
- Design for visually challenged community
- Education
  - Learning aid or a game

Secondary studies

- Education for blind
  - Compensatory skill development at early stages
  - Adapted curriculum
  - Hands-on/Montessori approaches
  - 3D models
- Focus on psychological development, rather than simply focusing on the blindness [Vygotsky]
- Need for inclusive learning rather than blind schools
  - Not even integrated learning [Carol Castellano]


SMT. KAMLA MEHTA DADAR SCHOOL FOR THE BLIND
श्रीमती कमला मेहता दादर अंधशाळा
CCTV


BERA FLUTE




TURKEY
IRAN
ARABIA
SAUDI
YEMEN
ETHIOPIA
INDIA
CHINESE


GEOMETRY TUTOR©
DESIGN PENDING


ANIMAL CELL
Under Elect. Microscope
KEY CARD
1. Pinocytic Vesicle
2. Cell Membrane
3. Vacuole
4. Centrosome
5. Golgi Bodies
6. Nucleus
7. Endoplasmic Reticulum
8. Lysosome
9. Mitochondrion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PERKINS BRAILLER
PERKINS SCHOOL FOR THE BLIND
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Interacted with

- **Smt. Kamla Mehta Dadar School for Blind**
  - **Teachers**
  - **Retired teacher**
- National Association for Blind
  - Retired director of education dept.
- St. Xaviers College (Xaviers Resource Centre for Visually Challenged)
  - Resource teachers
  - College students
- SIES College
  - Resource teachers
  - College students
- Antarchakshu
  - A workshop on inclusive learning for visually challenged

Questions

- What are the learning difficulties faced by visually impaired children?
- What are the teaching difficulties faced by teachers of visually impaired children?

Questions

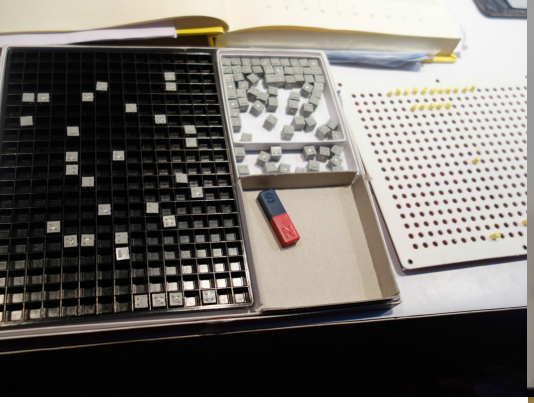
- What are the learning difficulties faced by visually impaired children?
- What are the teaching difficulties faced by teachers of visually impaired children?
  - Spatial skills
  - Language skills
  - Expression/paralanguage/posture
  - Sensory development
  - Concept development
  - Geometry
  - Angles
  - Measurements
  - Science experiments

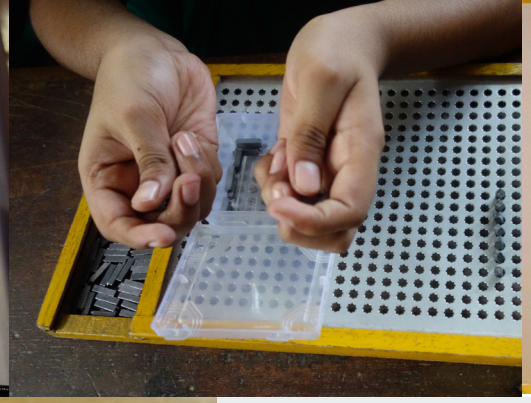
Findings

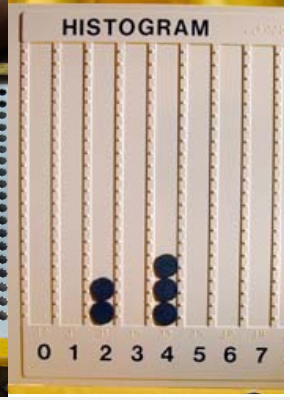
- **Maths and science** are not taught effectively in blind schools
  - Many topics are left out
  - Visual nature of these topics
  - Difficult to explain/comprehend
- Students eager to learn
  - and are capable
- Better maths and science education can open up more opportunities/jobs/further studies
- There is a need for inclusive learning

Survey of products

- For state-of-art and inspiration
- Focus on
  - Tools
  - Math and science products
  - Games/simulations



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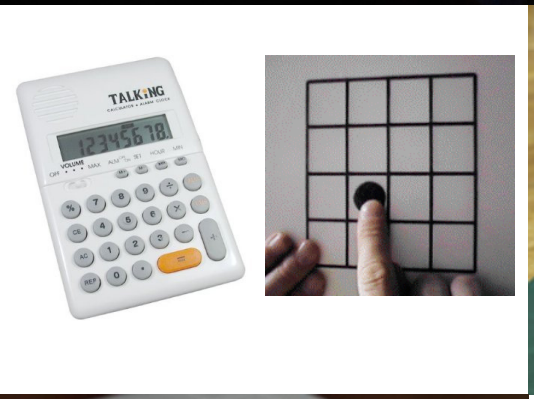
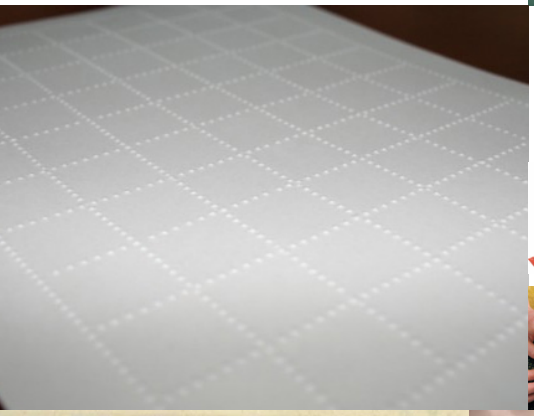
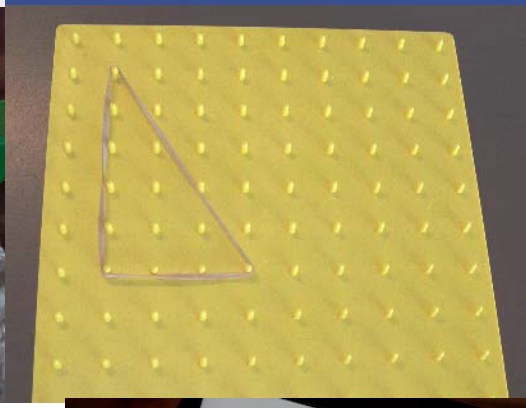
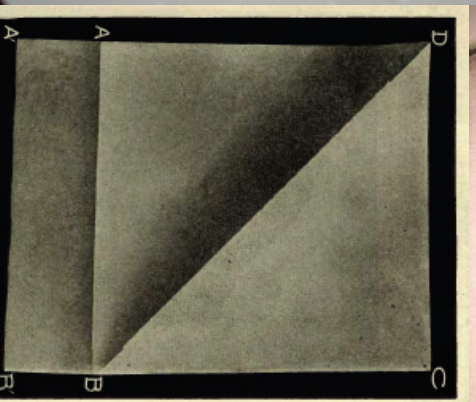
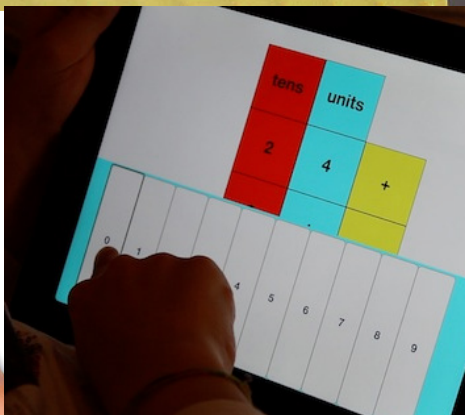

TALKING




BOSCH
VOX-Tape



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units
2
4
+

Choosing a topic

Choosing a topic

- Acids and Bases
- Maths tools
- Geometry
- Symmetry
- Colour
- Light
- Chemical Reactions

Choosing a topic

Acids and Bases
Maths tools
Geometry
Symmetry
Colour
Light
Chemical Reactions

CHEMISTRY

Chemistry

- *"Lessons are boring/uninteresting to students"*
- Topics are omitted/brushed through in blind schools
- Many concepts are visual in nature
  - Diagrams, colour changes, litmus paper, reactions
- Experiments can be unsafe
  - Glass, acids and bases
- Experiments are inaccessible
  - Equipment, measurement

Chemistry

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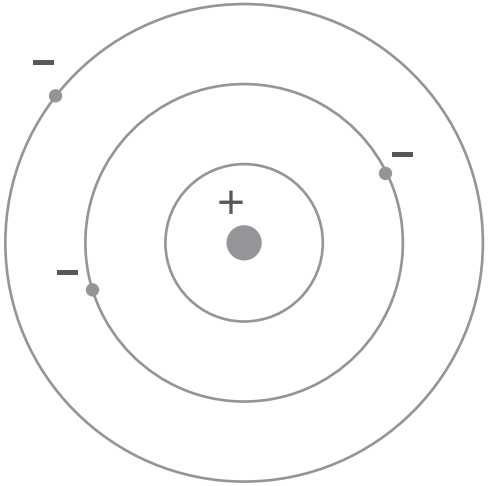
- Chemical reactions
- Acids, bases and salts
- Atomic structure

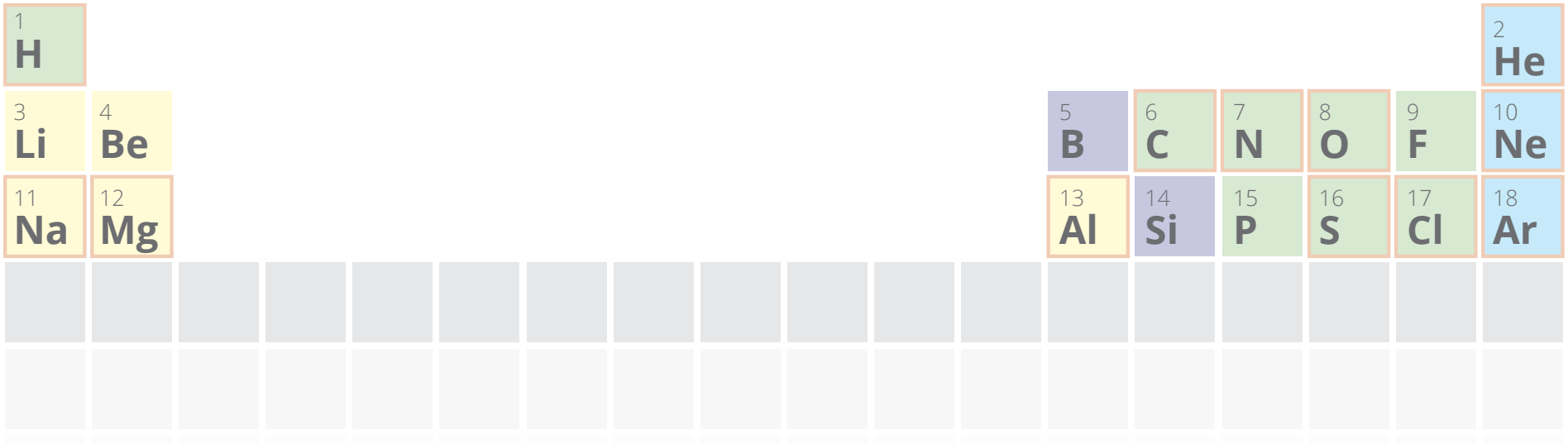
Atom

- Bohr-Rutherford Model
  - Positively charged nucleus with negatively charged electrons in fixed orbits

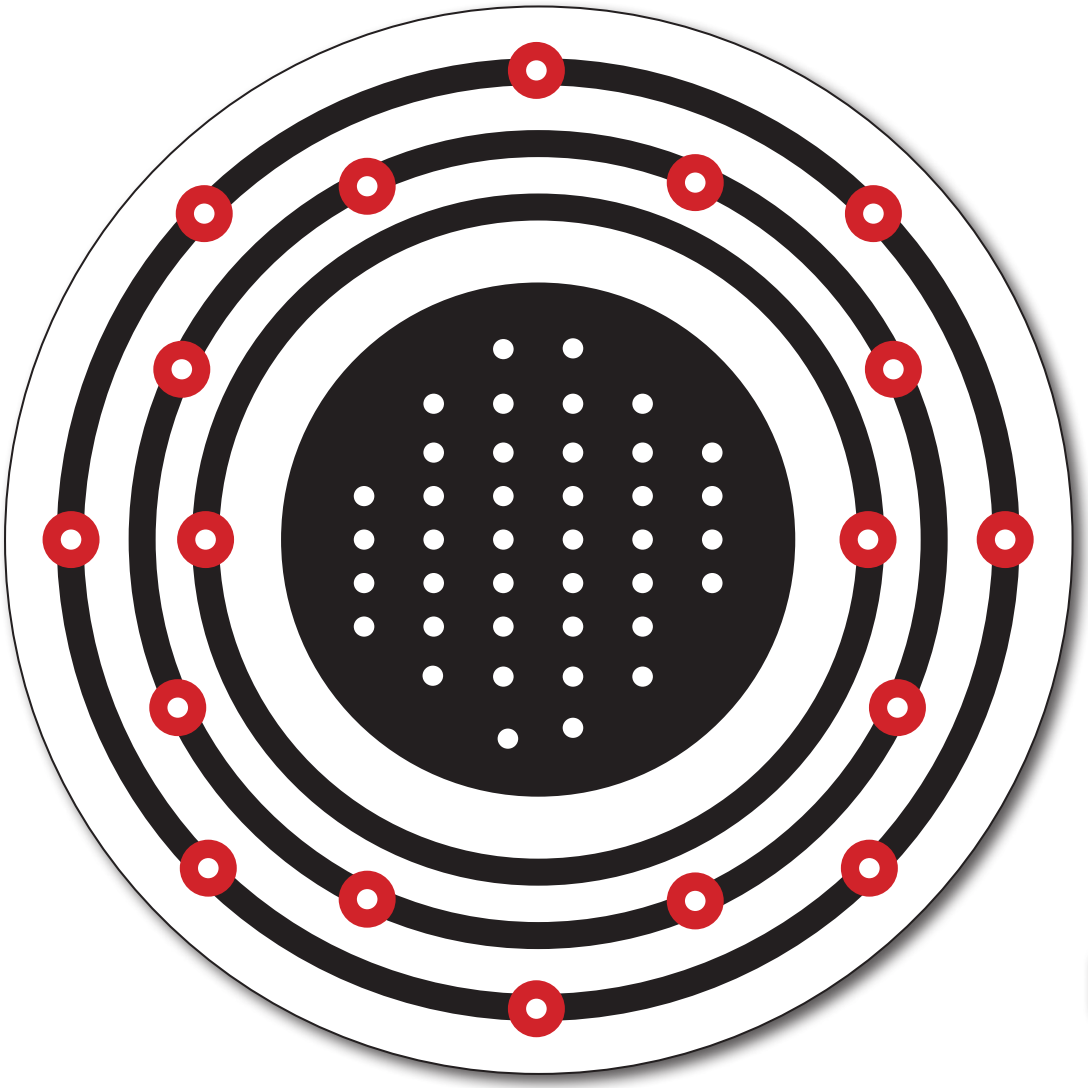


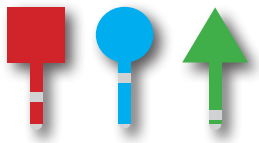
Learning goals

- The student should be able to explain the concept of atomic model with nucleus and orbits of electrons.
- The student should be able to state constituents of an atom —protons, neutrons and electrons.
- The student should be able to state how many electrons, protons and neutrons exist in specific elements.
- The student should be able to recall over time, the atomic number of an element, and some information about the element—e.g. its use, its properties. where it is found, etc.



Atomatic





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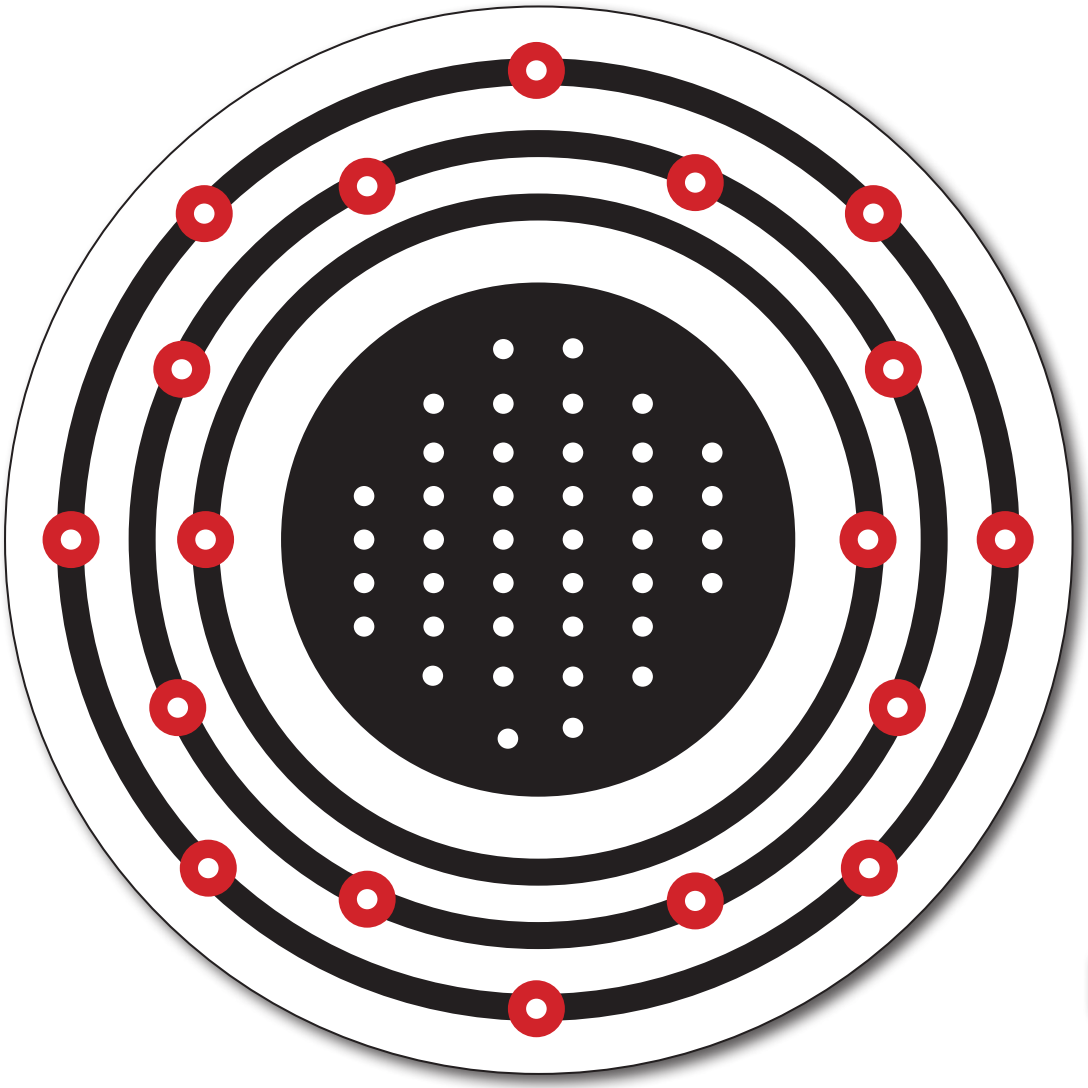
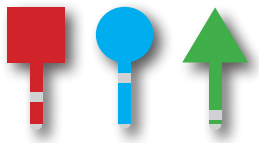


- Game-like interactive model
- To learn concepts of atom in a fun manner
- Inclusive (designed to be used by sighted or visually challenged children)



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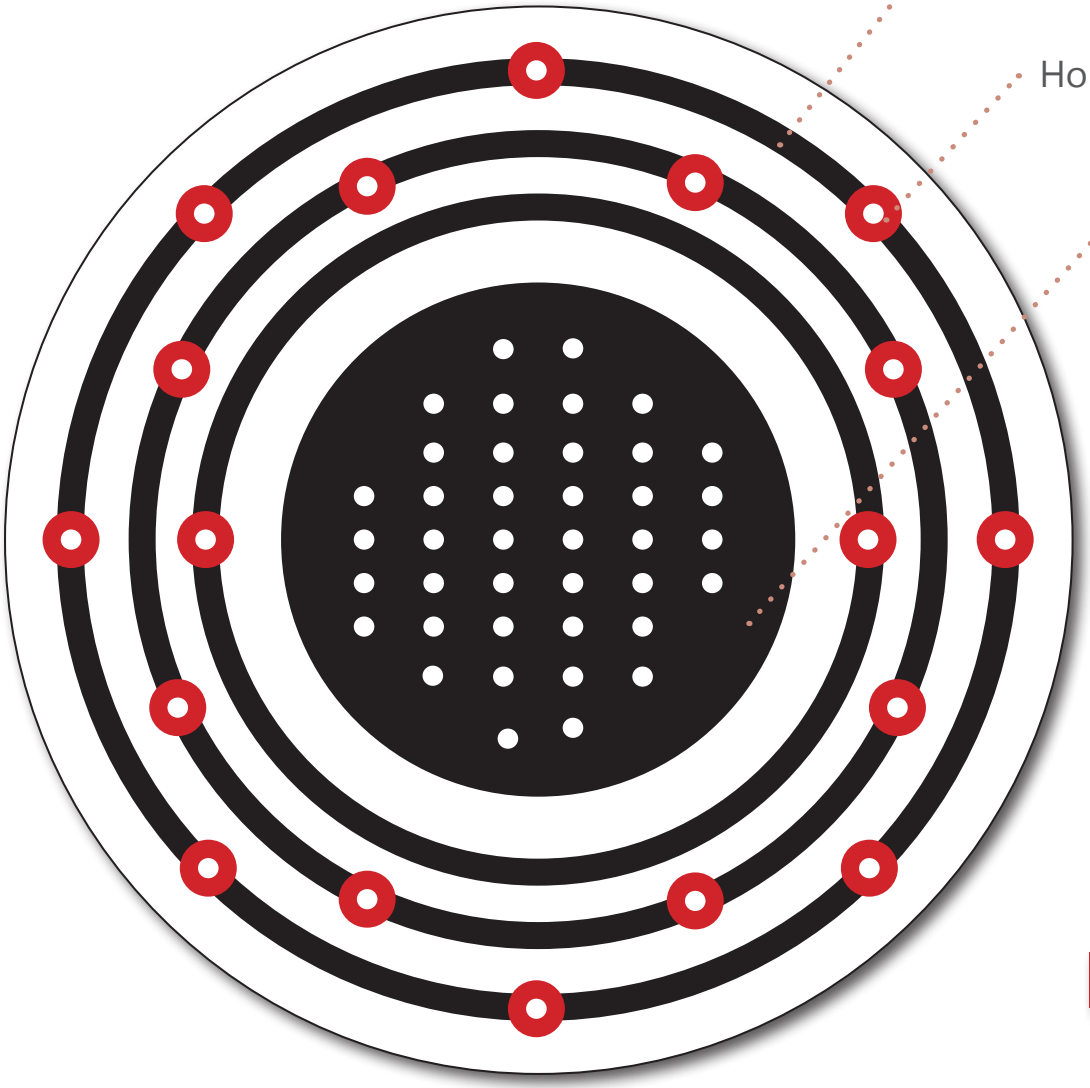
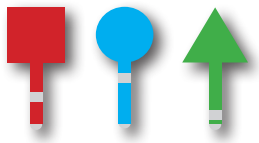


Electron orbits

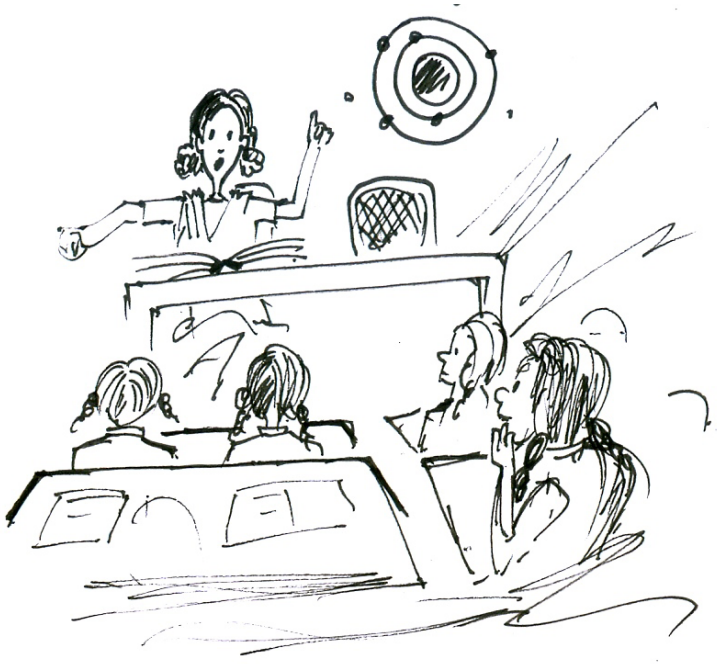
Holes for inserting electrons

Nucleus with
holes for inserting
protons and neutrons

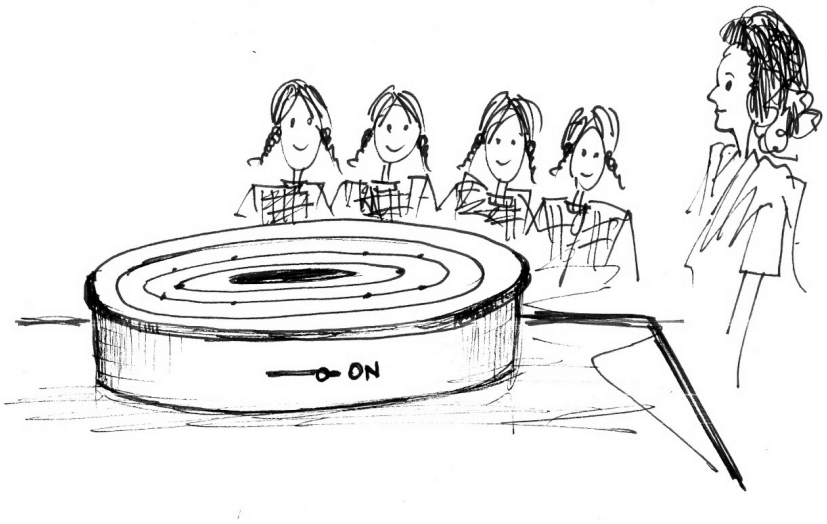
Pins
representing
protons
neutrons ane
electrons



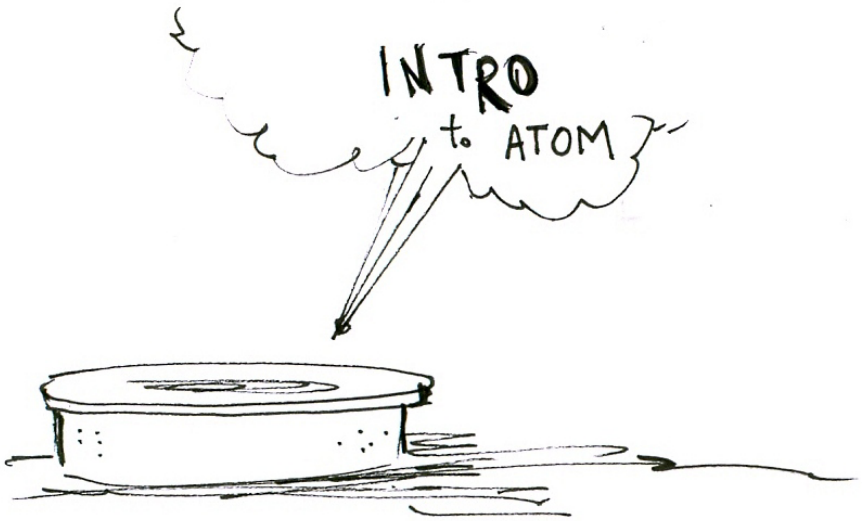
Demonstration



CLASS:
The teacher explains
the concept of atom using
the traditional method



LAB ACTIVITY:
The teacher introduces the model of the atom as a class activity in the lab



SWITCH ON:
An introduction message explaining the concept of atom, nucleus, orbits, electrons, protons, neutrons

Introduction (English transcription)

Narrator: Hi! Come on, let's play with atoms! But, let us learn a little about them first. You can start playing anytime by putting pegs in the board. Atoms are very very very tiny particles. Everything around you is made of atoms. The table, the universe, and even you! Atoms are so tiny that you would need over a million Carbon atoms to be as thick as one strand of your hair. The atom itself is made of three types of even smaller particles—protons, neutrons and electrons. Let's meet them:

Proton chorus: Hi. We are protons and we have a positive charge.

Neutron chorus: And we are neutrons. We have no charge, but we are good friends of the protons.

Proton: Yes, we neutrons and protons live together in the centre of the atom. Our home is called the nucleus.

Neutrons: The protons in the nucleus all have positive charges and can repel each other. I help them stay together in the atom.

Electron chorus : Hi, we are Electrons. We have a negative charge. We are not allowed into the nucleus so we move around it in orbits.

Proton: Yes, like planets around the sun.

Electron: Yes, but we can have 2 electrons in the first orbit, 8 in the second, 8 in the third and so on.

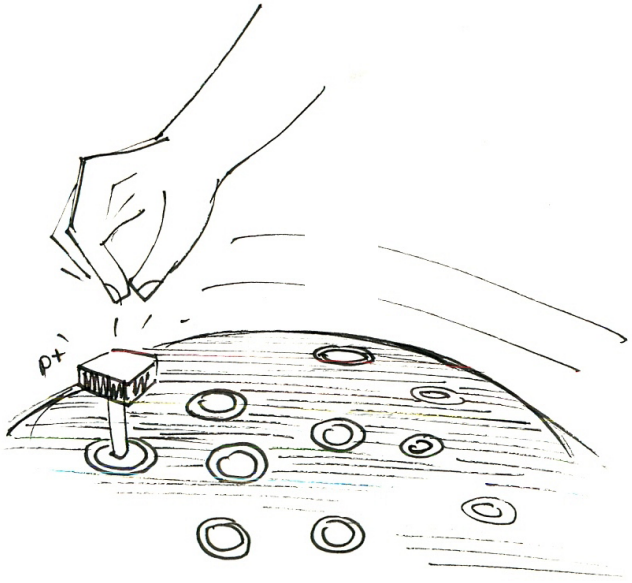
Neutron: Atoms need to have neutral charge. So we need equal number of electrons and protons in the atom. If the atom has 3 protons in the nucleus, it should also have 3 electrons in the orbits.

Proton: Together the three of us can make different types of atoms: Carbon, Hydrogen, Oxygen, and so on.

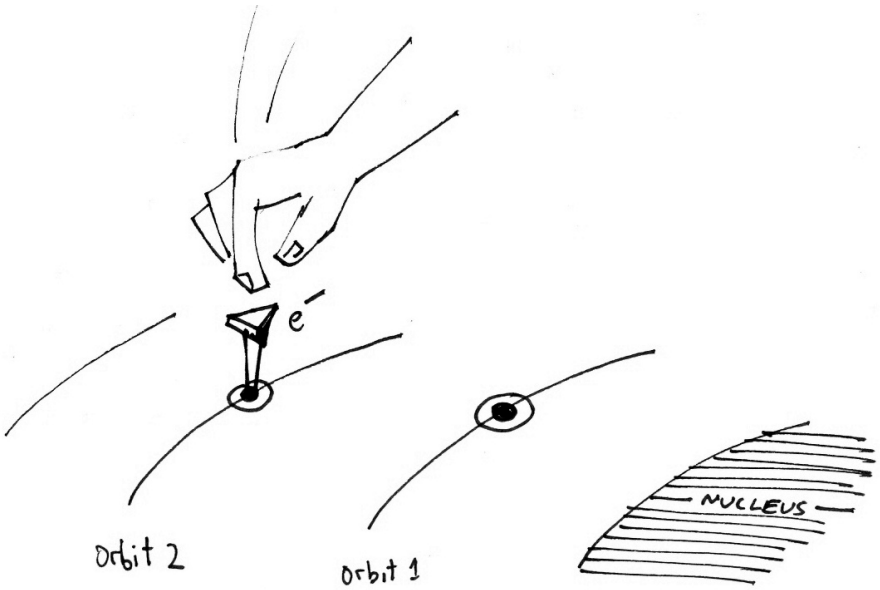
Narrator: Ok, It was nice meeting the protons, neutrons and electrons. Now let's play and make atoms.
Go on pick up a peg and put it in the board.

What is Hydrogen. What is its atomic number? How many protons, neutrons and electrons does it have?

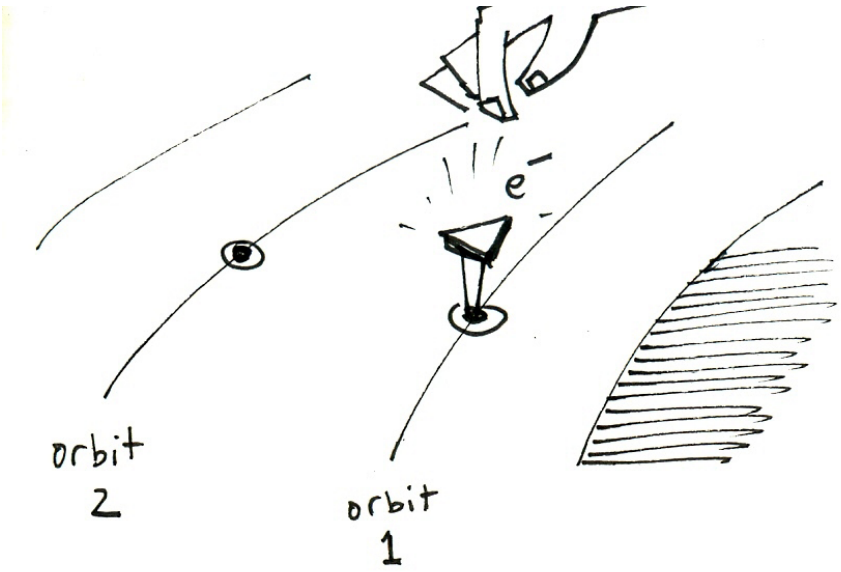
TASK
Teachers asks students questions based on the previous class, and then ask them to make an element



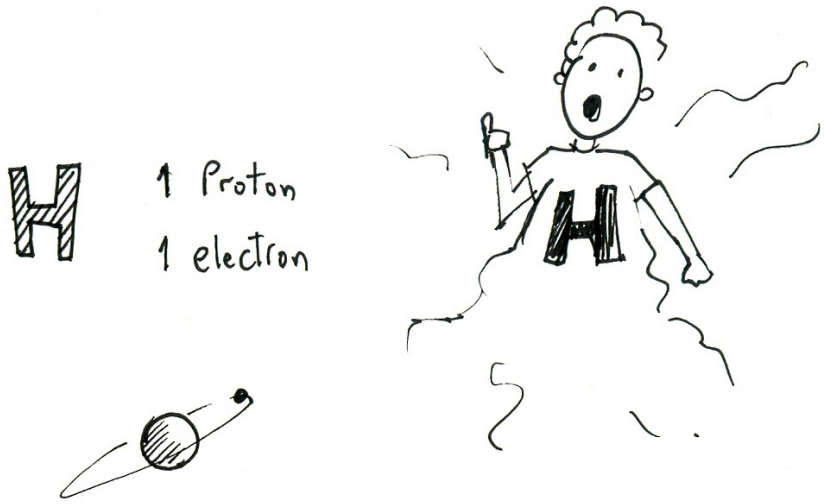
VOICE MESSAGES
Hints and guidance



ERRORS
are allowed, for
learning and fun



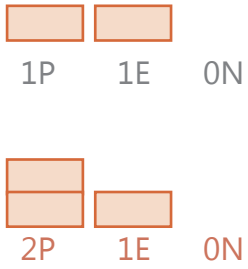
HINTS
and
GUIDANCE



FIRST-PERSON VOICE

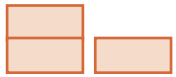
UNLOCK
Rhymes, poetries, songs or other interesting formats for presenting the information about the elements


1P
1E
0N

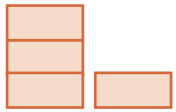


TONES
for identifying status/
count of board

1P 1E 0N

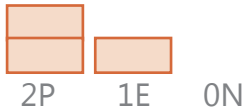


2P 1E 0N



3P 1E 0N

1P 1E 0N



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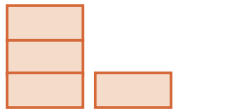

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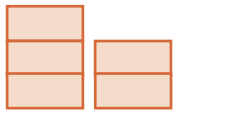

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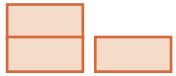
1P 1E 0N



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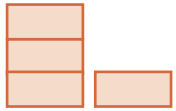

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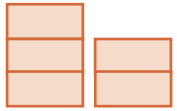

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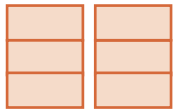
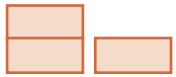


3P 3E 0N

1P 1E 0N



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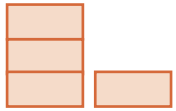

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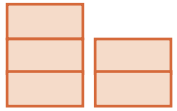

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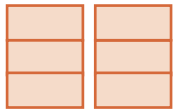
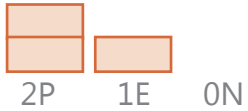


3P 3E 0N

IDLE/
IMPROPER DIRECTION/
CONFUSED

1P 1E 0N



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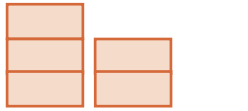

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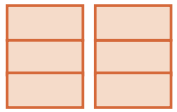

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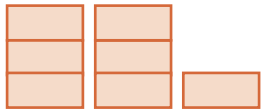
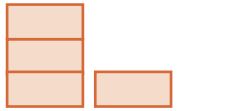


3P 3E 1N

1P 1E 0N

2P 1E 0N



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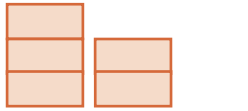

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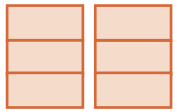

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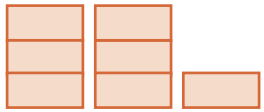
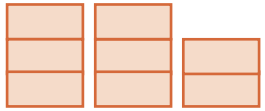
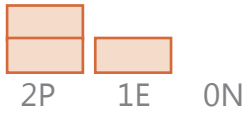


3P 3E 1N



3P 3E 2N

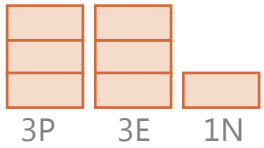

1P
1E
0N

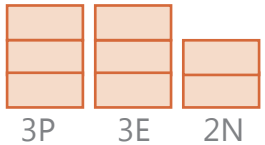

2P
1E
0N

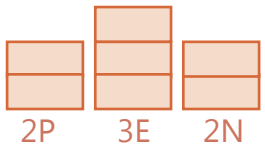

3P
1E
0N

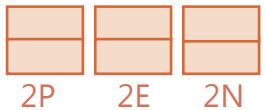

3P
2E
0N


3P
3E
0N


3P
3E
1N


3P
3E
2N


2P
3E
2N


2P
2E
2N

EXPLORE

Concept summary

- **Student explores** various combinations of protons, electrons and neutrons **to form an atom**
- The **model guides** the student towards correct combinations
- When the student **makes a valid atom,** the model speaks out the **properties of the constructed atom.**
- The discovery of the atom is made interesting by providing information **in the form of poems/songs/or other such interesting ways**
- The student tries to **unlock more complex atoms** by trying out various combinations of protons, electrons and neutrons

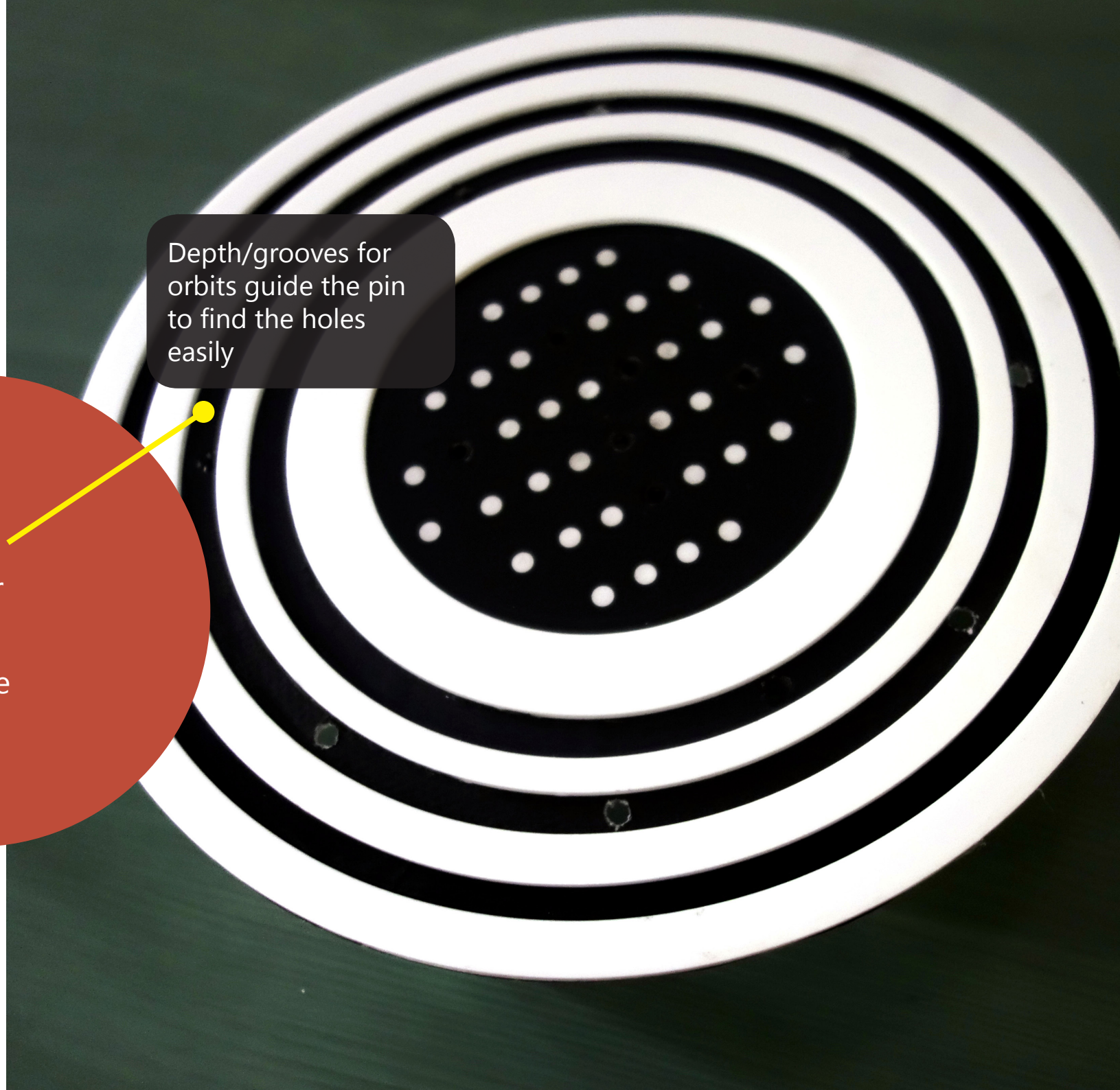
Design aspects

- Decisions based on primary and secondary research learning and initial prototype evaluation

Form

- Depth
- Colour
- Shape
- Texture

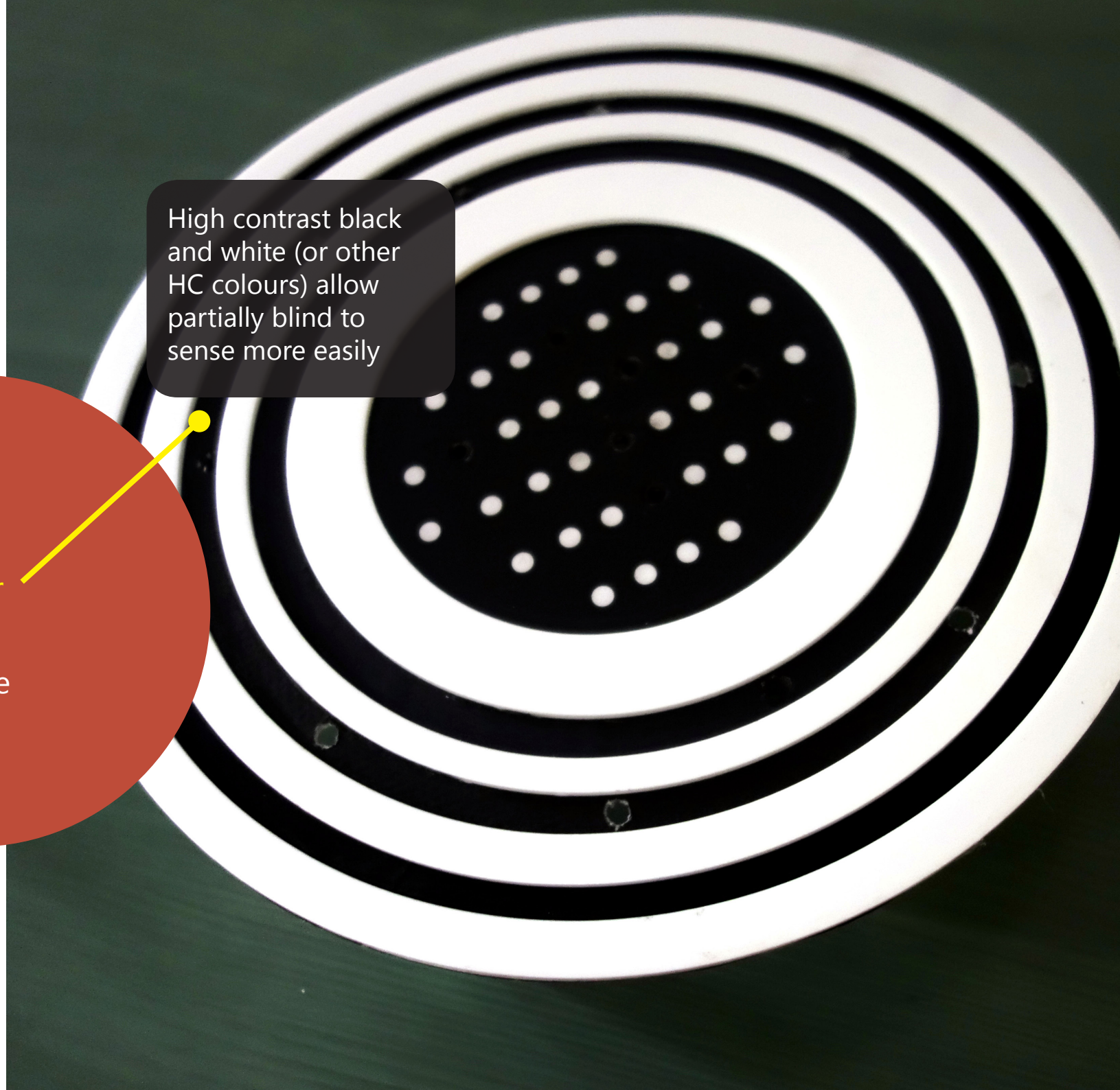
Depth/grooves for orbits guide the pin to find the holes easily



Form

- Depth
- Colour
- Shape
- Texture

High contrast black and white (or other HC colours) allow partially blind to sense more easily



Form

- Depth
- Colour
- Shape
- Texture

High contrast black and white (or other HC colours) allow partially blind to sense more easily

Form

- Depth
- Colour
- Shape
- Texture

Different shapes also help both blind and partially blind in sensing more easily

Form

- Depth
- Colour
- Shape
- Texture

Gradations of textures (from smooth nucleus to roughest outer orbit) to help distinguish orbits

Form

- Depth
- Colour
- Shape
- Texture

smooth surface for nucleus

Form

- Depth
- Colour
- Shape
- Texture

orbit 1: chart paper
orbit 2: water colour paper
orbit 3: cloth

Interaction

- Game-like
- Status of the board
- Sound and voice feed-back/guidance

Interaction

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Interaction

- Game-like
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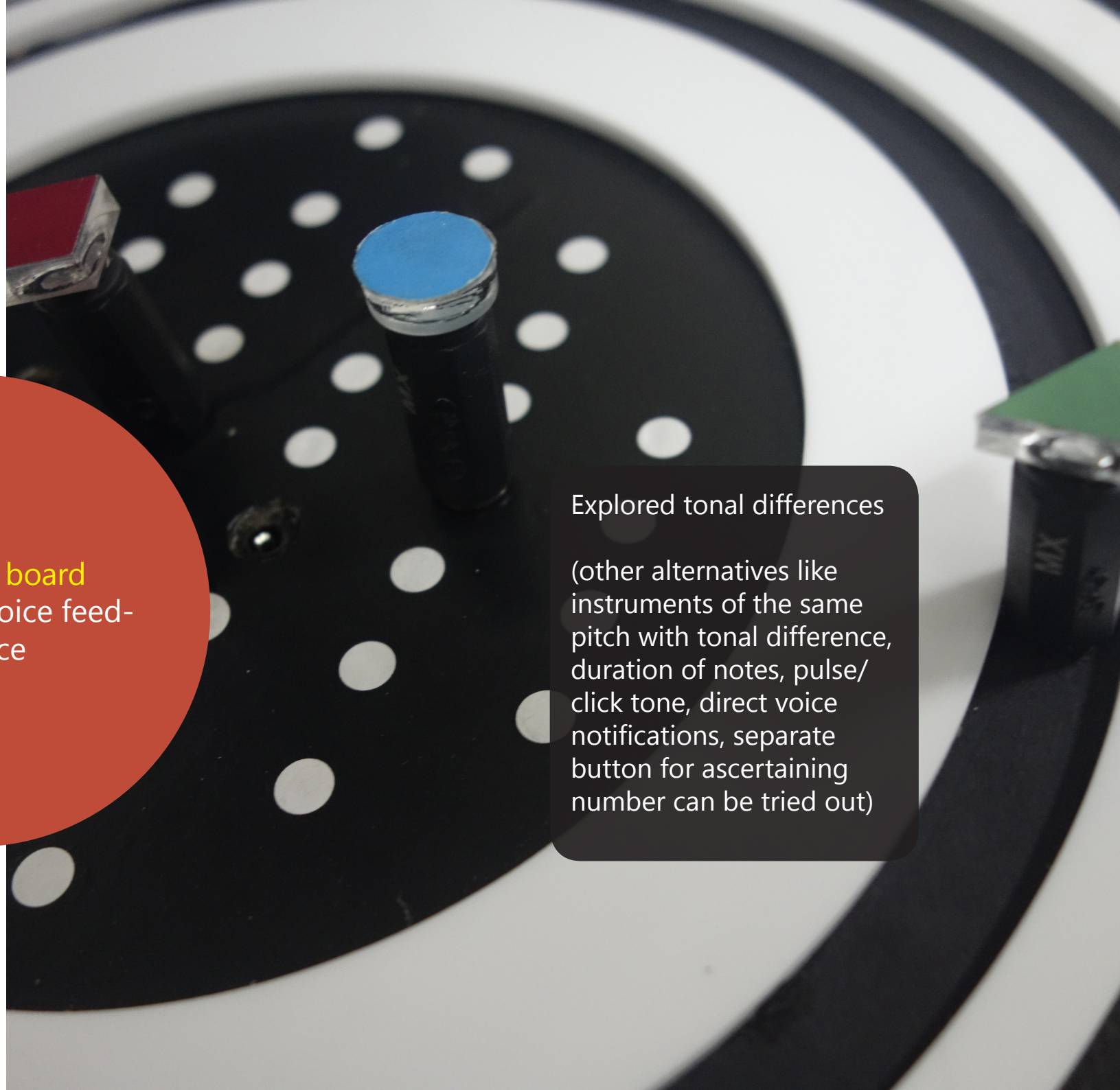
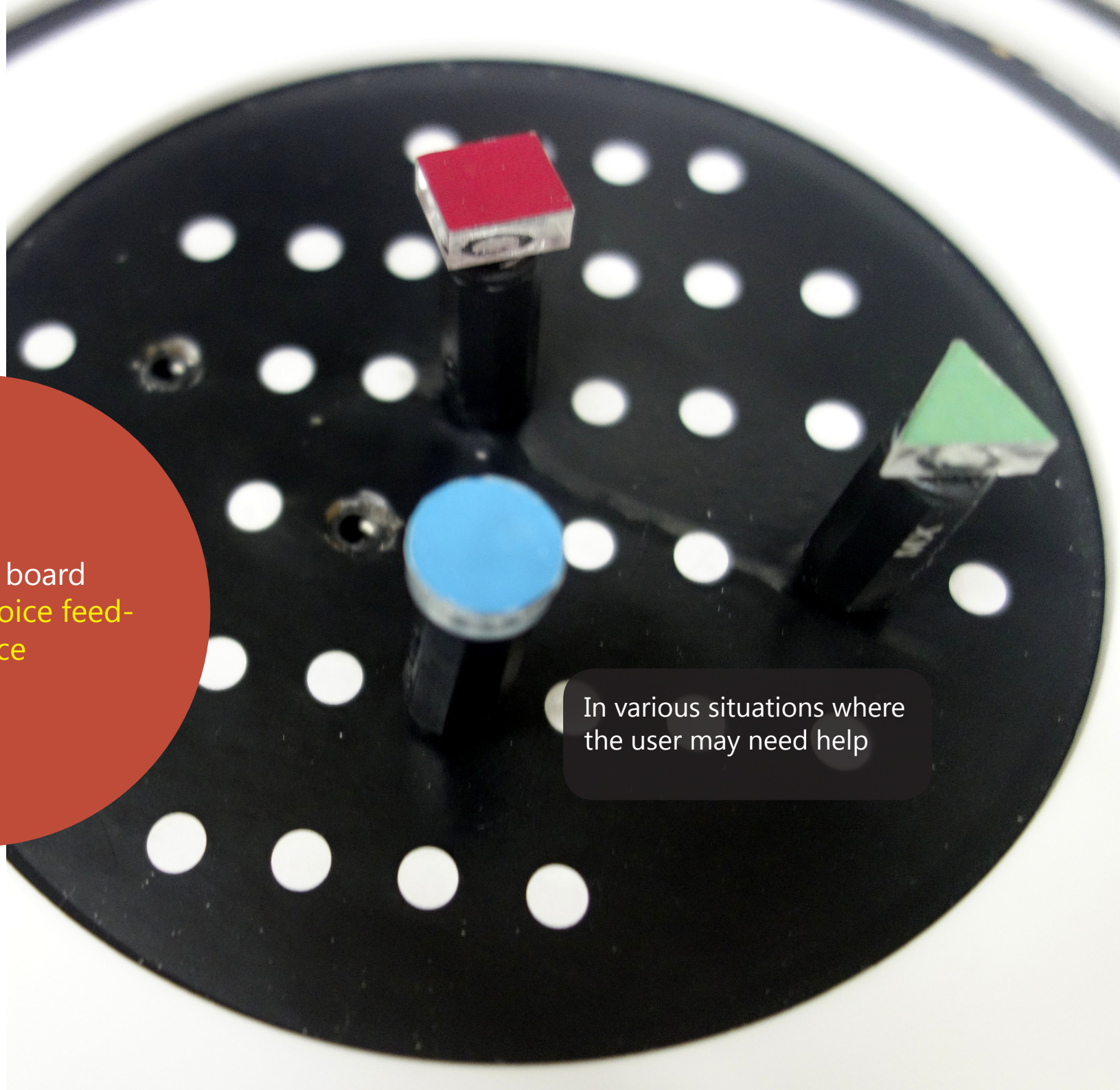


Explored tonal differences

(other alternatives like instruments of the same pitch with tonal difference, duration of notes, pulse/ click tone, direct voice notifications, separate button for ascertaining number can be tried out)

Interaction

- Game-like
- Status of the board
- Sound and voice feed-back/guidance



Learning

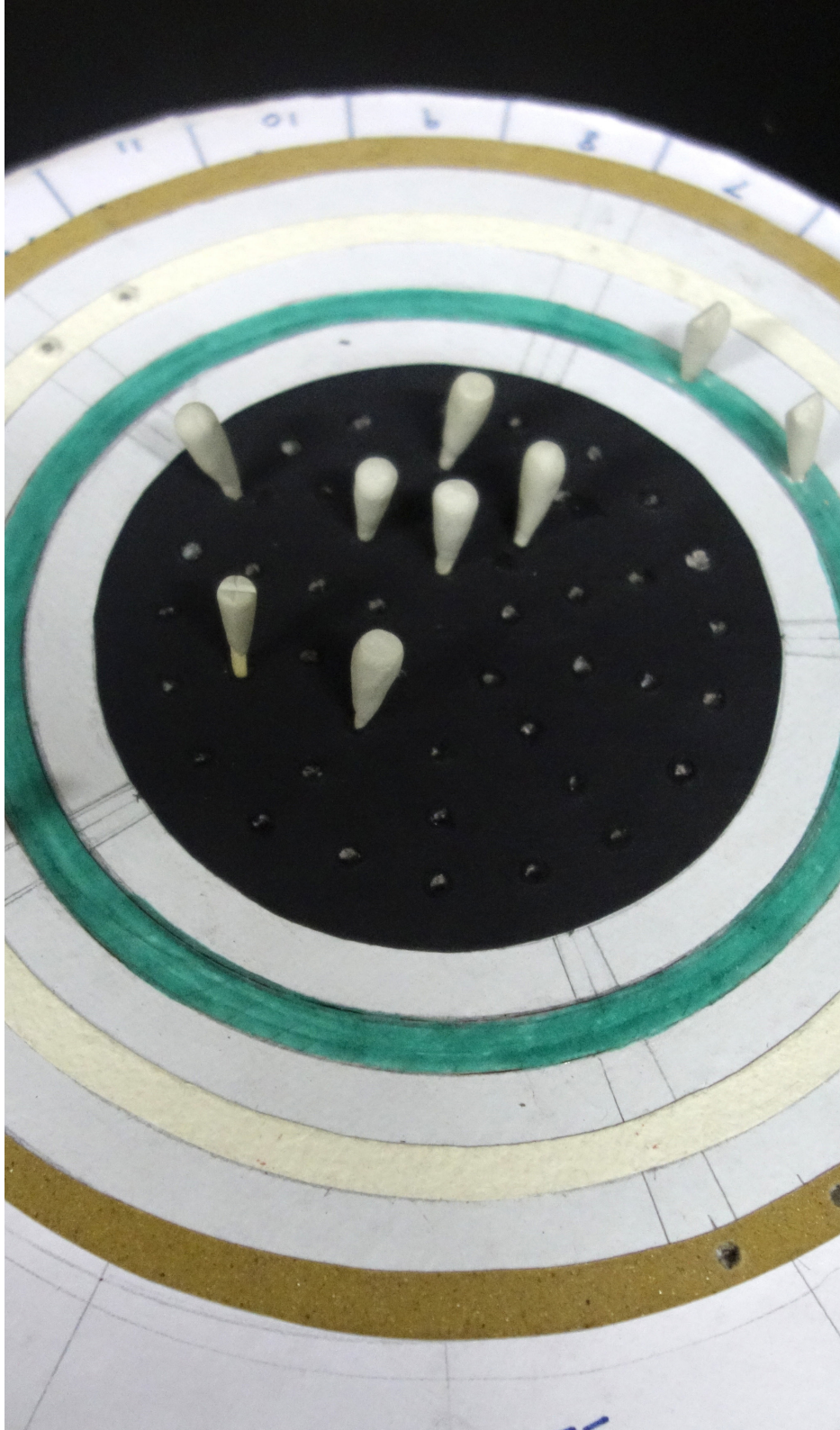
- Discovery approach
- Learn by making mistakes
- Provide small snippets at various points
- Encoded in rhymes

Limitations

- Board gets complex as the atomic number increases (restricted to 2 or 3 orbits)
- Technically complex as total 58 holes required to be assessed by the circuit (with 3 combination possible for each)
- Currently evaluated for 2 elements

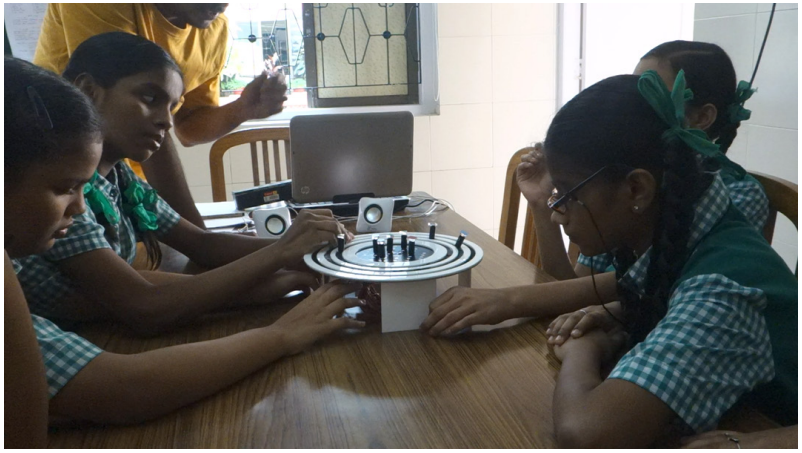
Evaluation

- Initial prototype (form)
- Evaluated (Reviewed) with
  - Teacher
  - Design student (toy and game)
  - 5 visually challenged college students (not much knowledge of atoms)
- Key findings
  - Sandpaper texture can harm sensitivity of fingers
  - The pins had different shapes, but were not visually distinguishible for partially blind
  - Orbits and holes were easily found
  - Initial training required (explanation of atom concept)
  - Try to match mental model to real (scatter the dots, explore 3D spherical form)
  - Reference sheet would help (periodic table)
  - Visual represention of + and - is different for visuall challenged



Evaluation

- Final prototype (form and interaction - wizard of Oz)
- Evaluation 1:
  - Class-room setting with 1 teacher and 5 students
  - Two std VIII, three std VII
  - Two partially blind, three blind
- Evaluation 2:
  - Review by 6 college students (without teacher-3 partially blind, 3 blind)
  - BA students, had some knowledge of atoms
  - Review by resource teachers



Evaluation

- Pre-Questions
  - Assessment of knowledge of terms (atoms, neutrons, protons, electrons, orbit, positive and negative), and elements known.
- Training
  - Explained the concept of atom, protons, neutrons, electrons.
  - Explained the board, and allowed the students to explore and find the holes
  - Explained the pins.
- Task was to try making an element by putting pins in the board (as they felt like)
  - Teacher could assist them and try to inform them as she would in a class.
- Post-Questions
  - Assessment of what information they have retained from the poems they listened to.
- Feedback

Evaluation

- Observations
  - Students enjoyed the poetry and the error sounds
  - Able to retain some amount of information in one go
  - They could easily identify the pins
  - Inconsistent spacing of orbits helped in identifying the orbit number better than the texture (can possible save on the cost, by using this approach?)
  - Textures were too subtle, but distinguishable
  - Followed grooves with fingers rather than pin
  - If an atomic number is known (eg. C), the user might put all protons first, followed by electrons and neutrons
  - Tonal differences were not easy to identify
  - Voice clarity was appriciated

Evaluation

- Feedback
  - Add a voice snippet explaining the board
  - Pins can be of shapes identifying +, - and neutral charge
  - Explore 3D model
  - Blue colour orbits
  - Textures on side of pin, dots on top
  - Multiple levels for beginners and advanced
  - Different tone of language for advanced students
  - Add white border to the holes

Conclusion

- Product
  - The product seems to work as a concept with young children (VII, VIII).
  - The rhyme/songs are liked by the children. More forms of presenting information can be explored.
  - Teachers can use it as a effective tool to explain concepts to students in an interesting manner.
  - Tone of voice and game challenges can be modified based on the levels of students.
  - Alternate strategies needs to be worked out for identifying the state of the board at a glance
- Learning
  - Use of various tools/material (product design studios, electronics)
  - Electronics
  - Arduino and Processing
  - Designing for visually challenged and inclusivity
  - Voice and sound as interfaces

Future work

- Integrate concepts of isotopes and valencies
- Implement the rest of the slots in the board
- Work out form details based on the evaluation feedback
- Evaluate more strategies that users would use while operating the board,
  - and design messages for more cases.
- Implement the game concepts, for advanced modes of operating the model
  - Test modes, challenge modes, game mode
- Multi-lingual
  - Hindi, English, Marathi
- Explore further in sound based interactions
- Explore 3D alternative (spherical) which is closer to the theory of the atomic structure

Thank you

Smt. Kamla Mehta Dadar School for Blind

Teachers

Retired teacher

National Association for Blind

Retired director of education

St. Xaviers College (Xaviers Resource Centre for Visually Challenged

Resource teachers

College students

SIES College

Resource teachers

College students

Antarchakshu

(A workshop on inclusive learning for visually challenged)