

# Emerging Technologies for Effective Teaching & Learning

Continuing Education Program for Next Education India Pvt Ltd

Conducted by Educational Technology, IIT Bombay

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# Effective integration of technology

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Sahana Murthy  
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Strong pedagogy + meaningful technology

trumps

Sophisticated technology + mediocre pedagogy

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Technology must be chosen so that it can support meaningful pedagogy.  
Pedagogy must be designed so that it meaningfully exploits technology.



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Pedagogy must be designed so that it meaningfully exploits technology.



## Frequently asked questions during demo

How to use the technology well?

How to incorporate technology in the teaching-learning process?

What should a teacher do with the technology in the classroom for effective learning?

...

*How to effectively integrate technology?*



# Getting to know each other better

## Each one say one

- Your name
- Your school
- Which technology do you want to “effectively integrate”  
– list one.

# Which technology do you want to effectively integrate



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# Frequently asked questions during demo

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...

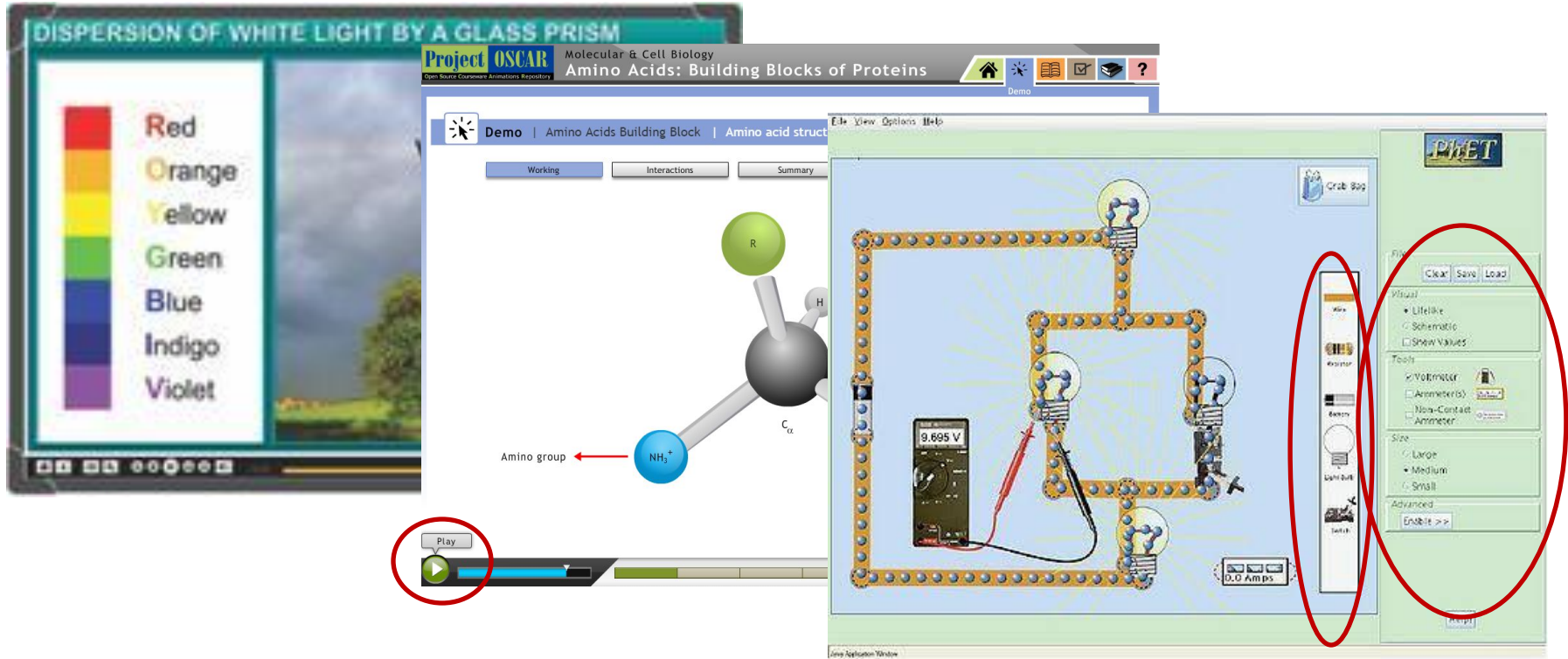
*How to effectively integrate technology?*



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# Visualizations (familiar, commonly available)

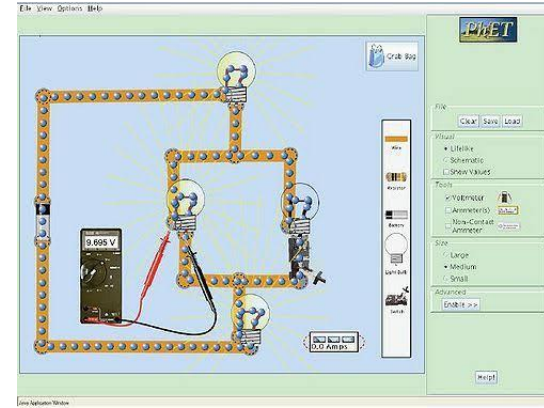
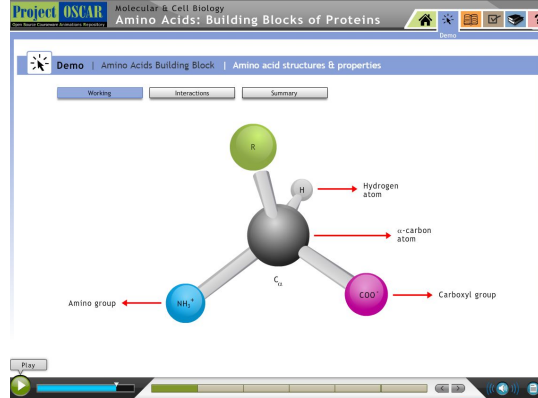
# Visualizations in teaching-learning



The image displays three educational software interfaces:

- Project OSCAR:** A window titled "DISPERSION OF WHITE LIGHT BY A GLASS PRISM" showing a color spectrum from Red to Violet. The text "Project OSCAR" and "Open Source Courseware Animations Repository" is visible.
- Amino Acids Building Block:** A molecular model of an amino acid with a central carbon atom ( $C_{\alpha}$ ) bonded to a hydrogen atom (H), a variable side chain (R), and an amino group ( $NH_3^+$ ). A label "Amino group" points to the  $NH_3^+$  group. The interface includes "Working", "Interactions", and "Summary" tabs.
- PHET Circuit Construction Kit:** A circuit simulation window showing a battery, a voltmeter, and a light bulb. The voltmeter displays "9.695 V". The interface includes a "Play" button, a progress bar, and a control panel with "Clear", "Save", and "Load" buttons. A red circle highlights the "Play" button and the control panel.

# Visualizations in teaching-learning



Visualizations – videos, animations, interactive simulations  
Many repositories  
Shown to provide learning benefits





# Why do teachers use visualizations in class?

**THINK:** Write one purpose for using viz, including an example from your topic. (1 min)



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**THINK:** Write one purpose for using viz, including an example from your topic. (1 min)

**PAIR:** Turn to your neighbour(s), examine each other's purposes. Are they similar or different?

Together – come up with at least two different purposes. (3 min)



# Why do teachers use visualizations in class?

**THINK:** Write one purpose for using viz, including an example from your topic. (1 min)

**PAIR:** Turn to your neighbour(s), examine each other's purposes. Are they similar or different?

Together – come up with at least two different purposes. (3 min)

**SHARE:** Share a purpose from your group with all participants.

# Why do teachers use visualizations in class?



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# Why do teachers use visualizations in class?

- Make invisible visible– atoms, cells ...
- Ability to visualize – 3D, internals ...
- Improved conceptual understanding
- Higher motivation, engagement
- Easier / less boring than blackboard

*Learning goals*

*Imp goal but not always same as learning*

*Sometimes we have this goal*

# How do most instructors use visualizations in class?



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# How do most instructors use visualizations in class?



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- Teacher will play/ show/ demonstrate visualization, along with narrative explanation
- Students will watch and ask for clarification if needed

# Vote



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Does demo + explanation of visualizations improve learning?

- 1) Yes
- 2) No



# Visualizations and learning: Evidence from research



[Demo + explanation] by itself is not effective

Potential benefits of visualization is lost if students merely watch & hear

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Active-learning strategy with visualization led to improved outcomes

(Laasko et al 2009; Windschitl & Andre 1998, Banerjee, Murthy & Iyer 2015)

# Example – active learning with visualization



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## Example – active learning with visualization

A helium balloon is attached to a string tied to the bottom of a cart on wheels. The sides of the cart are encased in clear plastic. A person will abruptly push the cart to the left.



## Example – active learning with visualization

A helium balloon is attached to a string tied to the bottom of a cart on wheels. The sides of the cart are encased in clear plastic. A person will abruptly push the cart to the left.

*VOTE - Will the balloon move?*

- 1) No it will stay in place
- 2) Yes, backward
- 3) Yes, forward



# Example – active learning with visualization

- Watch the video.
- *Did the balloon move?*
  - 1) No it stayed in place
  - 2) Yes it moved backward
  - 3) Yes it moved forward



# Example – active learning with visualization

- Watch the video.
- *Did the balloon move?*
  - 1) No it stayed in place
  - 2) Yes it moved backward
  - 3) Yes it moved forward

*Did you change your answer?*



# Summary – active learning with visualization

## Observe phase

### TEACHER:

- Play viz upto the point the stimulus is shown.
- PAUSE before result. Don't show rest of viz yet.

### STUDENTS:

Observe first part of viz

## Predict phase

### TEACHER:

- Ask students to make prediction: “What will happen if ...”

### STUDENTS:

- Make prediction – write / vote
- Discuss w each other

## Check & explain phase

### TEACHER:

- Shows rest of viz, which contains result

### STUDENTS:

- Check their prediction by viewing the result in viz
- Explain reason and discrepancies if any



# Program Visualization

Predict output (or next step) of program

### Observe Step 4 & Predict step 5

Pointer Arithmetic
Text

Back
Forward

Program Code:

```
#include <stdlib.h>
int main() {
    char x[3] = {'a', 'b', 'c'};
    char* y = x;
    printf("Element 0 = %c\n", *y);
    printf("Element 1 = %c\n", *(y+1));
    printf("Element 2 = %c\n", *(y+2));
    printf("Element 1 = %c\n", *(-y));
    printf("Element 1 = %c\n", *(y++));
    printf("Element 2 = %c\n", *y);
    printf("Element ? = %c\n", *(y+1));
    return 0;
}
```

Program Output:

```
Element 1 = b
```

Explanation:

Here, the expression "y+1" returns the address 61, which is then dereferenced by \* to return the value stored at 61.

Addr...	+ 0	+ 1	+ 2	+ 3	Variable
60	a	b	c		x
56				60	y
52					
48					
44					
40					
36					
32					
28					
24					
20					
16					
12					
8	program code	program code	program code	program code	
4	program code	program code	program code	program code	
0	reserved by the operating system				

# Program Visualization: Study

Controlled study, 2 groups:  
 Viewing group (95 students)  
 Prediction group (136 students)

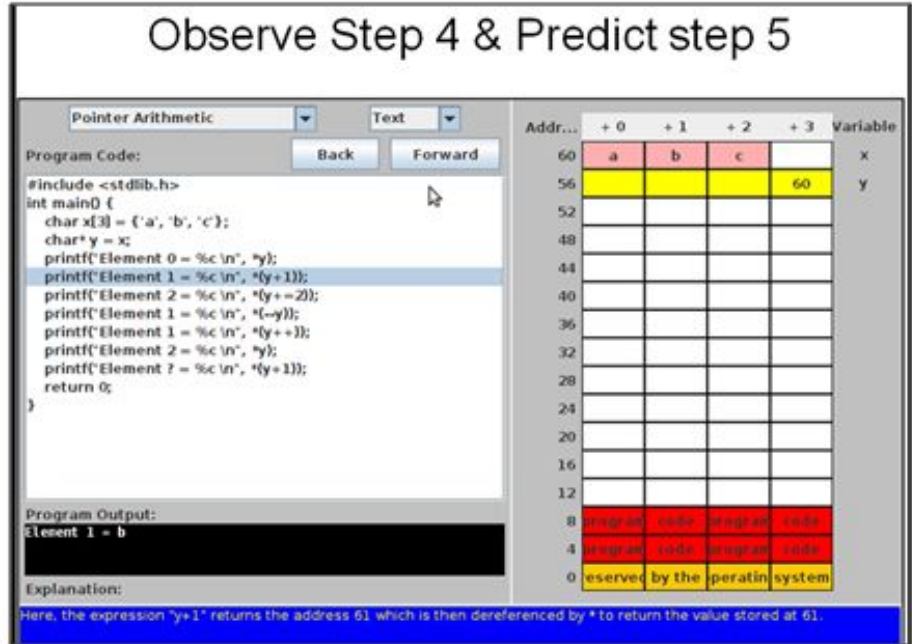
Results:

For Prediction group

- Higher engagement in class
- Higher rate of problem-solving

(Banerjee, Murthy & Iyer 2015)

Observe Step 4 & Predict step 5



The screenshot shows a program visualization interface. On the left, the C code is displayed with the following content:

```

#include <stdlib.h>
int main() {
    char x[3] = {'a', 'b', 'c'};
    char* y = x;
    printf("Element 0 = %c\n", *y);
    printf("Element 1 = %c\n", *(y+1));
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    printf("Element 1 = %c\n", *(y++));
    printf("Element 2 = %c\n", *y);
    printf("Element ? = %c\n", *(y+1));
    return 0;
}
  
```

Below the code, the program output shows "Element 1 = b". The explanation states: "Here, the expression 'y+1' returns the address 61, which is then dereferenced by \* to return the value stored at 61."

On the right, a memory table is shown with the following structure:

Addr...	+ 0	+ 1	+ 2	+ 3	Variable
60	a	b	c		x
56				60	y
52					
48					
44					
40					
36					
32					
28					
24					
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12					
8	program code	program code	program code	program code	
4	program code	program code	program code	program code	
0	reserved by the	operating system			

# Takeaway



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Visualizations can lead to improved learning outcomes only if accompanied by active learning strategies.

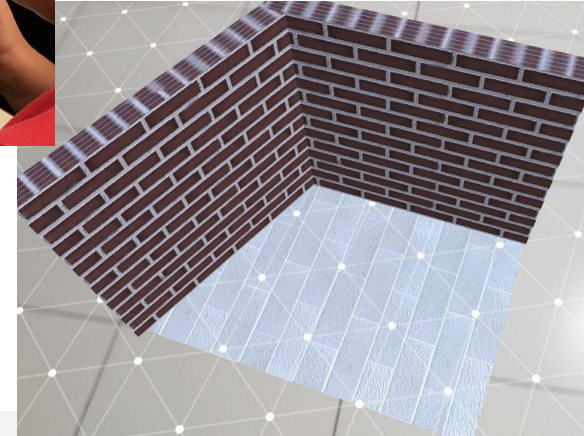


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# Augmented Reality

# What are our intended goals for using AR?

- Visualize 3D objects
- Rotate and view
- Measure angles in along various orientations
- ...

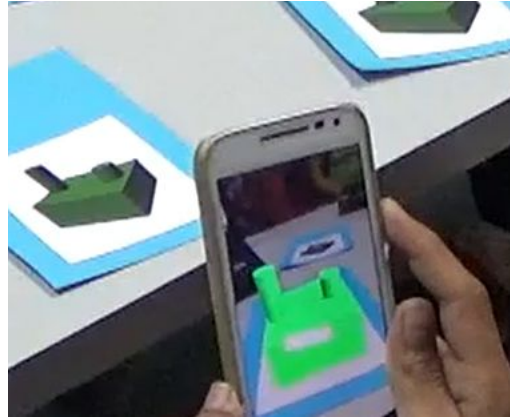


# What does AR technology provide?

## Affordances:

- Render 3D shapes
- Ability to rotate
- Ability to manipulate shapes

...





# Active Learning with AR:

Basic Mantra : Do learner-centric activity using AR;  
Do not leave their interaction with technology unguided

# Active Learning with AR:

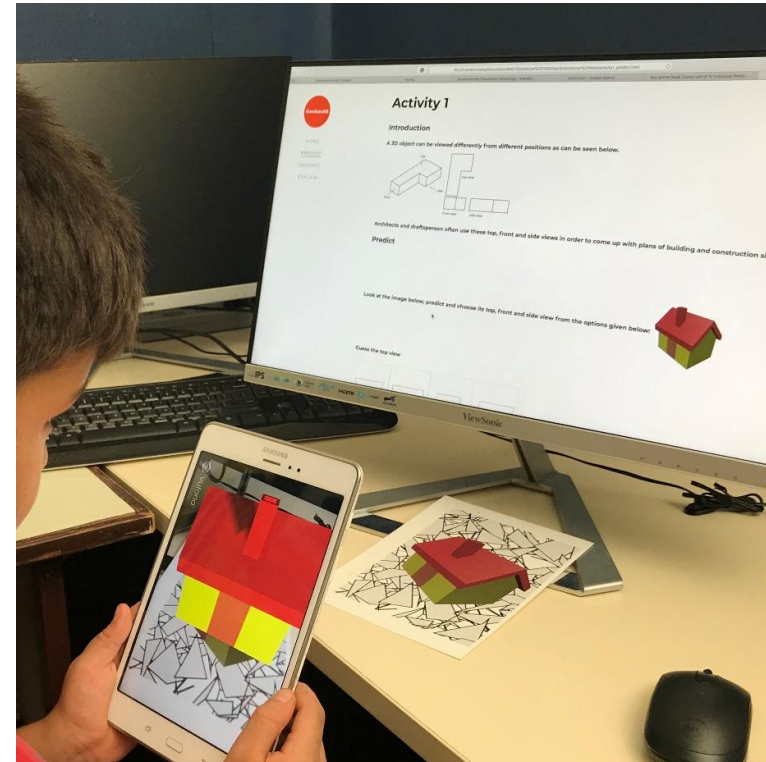


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Recall from yesterday's demo:

Learning activity with GeoSolvAR

Predict-Observe-Explain strategy





# Active Learning with AR:

Basic Mantra : Do learner-centric activity using AR;  
Do not leave their interaction with technology unguided

## TEACHER:

Poses an activity question to predict output for given input parameters



## STUDENT:

Makes the predictions.  
Uses AR to verify their predictions from observations made with AR  
*Example: Top, Side, Front view of given object*

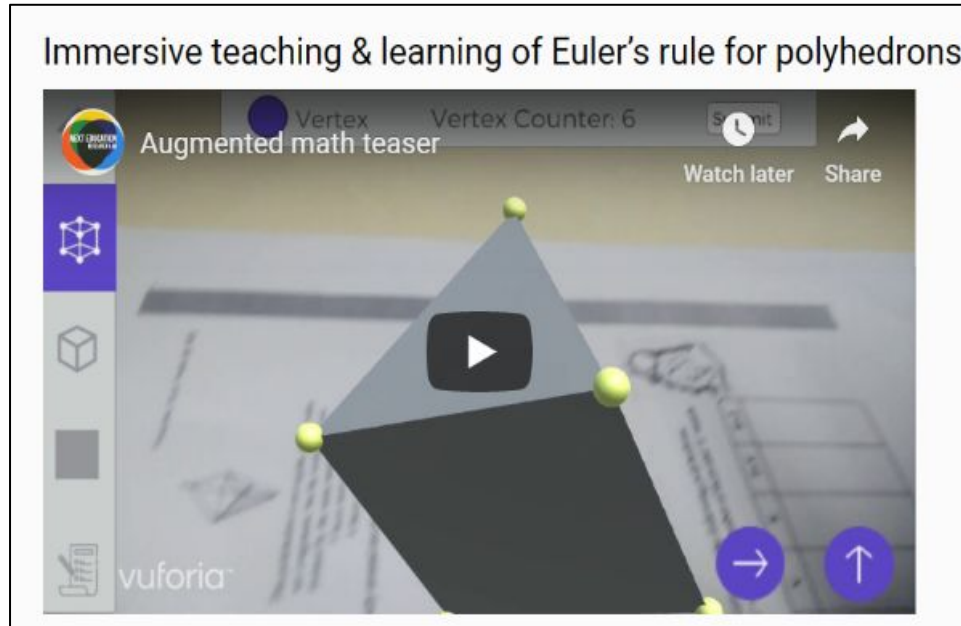


## TEACHER + STUDENT:

Discusses explanation for their observations

# Active Learning with AR:

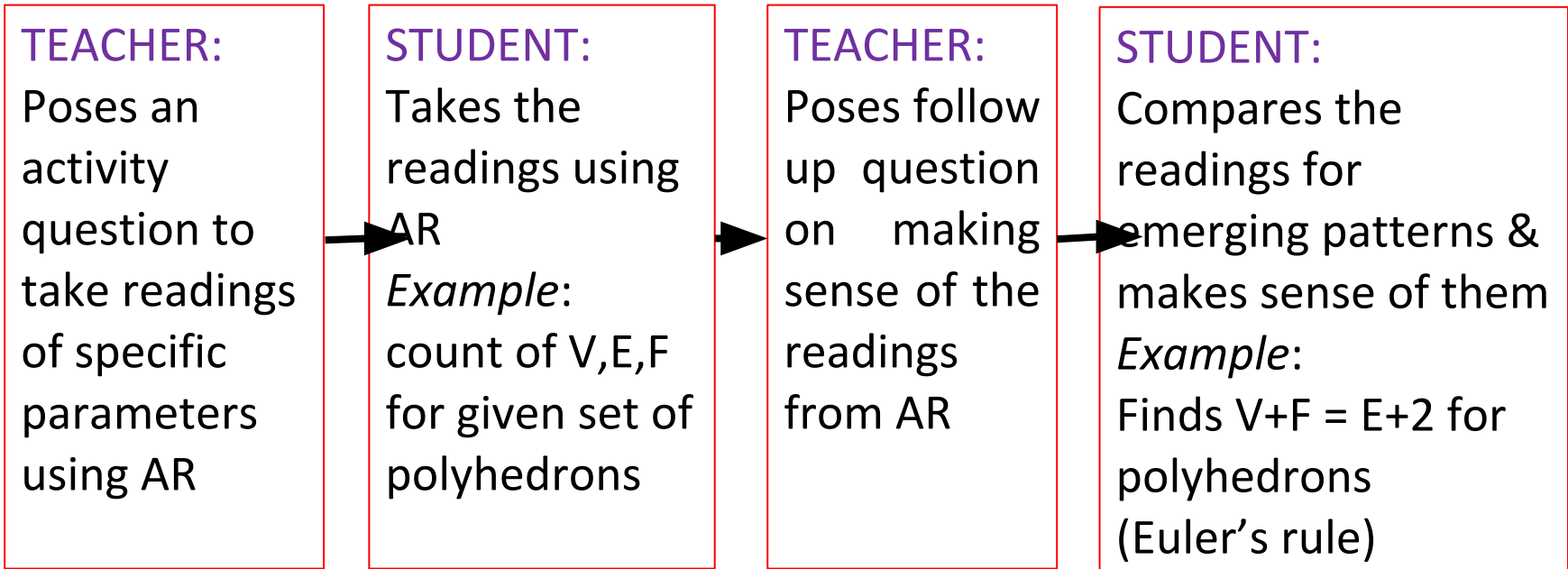
Recall from yesterday's demo :





# Active Learning with AR:

Basic Mantra : Do learner-centric activity using AR;  
Do not leave their interaction with technology unguided



# Pilot Study

8 participants, 5 activities each

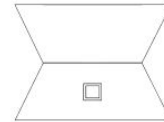
Audio and Video recordings,  
interviews, QUIS  
questionnaire, Pre-post test

Findings (usability):

- Perceived ease of use – high
- Students frequently used AR to rotate, while making prediction

## Activity Type I

Look at the image below, predict and choose its top view from the given options below



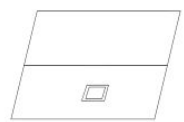
**A**



**B**



**C**



**D**



# Design principles

Make sure design goal is clear:

Learning? Engagement? Efficiency? Accessibility? (not all the same)

Create pedagogical activities to harness technology affordance

Create a learning activity with focus question, requiring the use of tech

Use active learning during implementation

Students do activity, get feedback while exploring technology

Evaluate if initial goal is achieved



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Tea Break 😊



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# Vote – Math Blaster game



# Vote – Math Blaster game



Is this an instance of effective integration of technology?

1) Yes 2) No

# Vote – Blood Typing game



**The Blood Typing game**

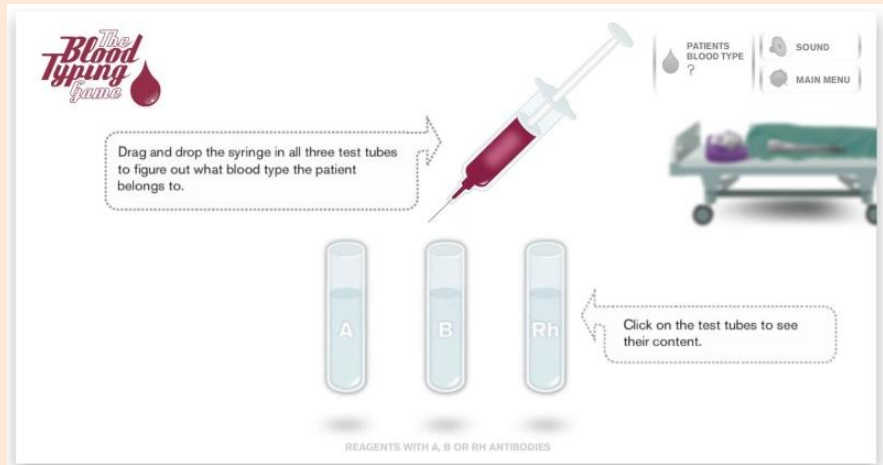
*Car crash victims*

SOUND  
MAIN MENU



Hi and welcome to the emergency department at this hospital!  
Your challenge is to save three patients who have been in a car accident and need blood transfusions. It is your job to blood type each patient and give them the correct blood. Try to avoid making mistakes or the patient's condition will deteriorate! If you make no mistakes you will get all five out of five blood drops in the end.

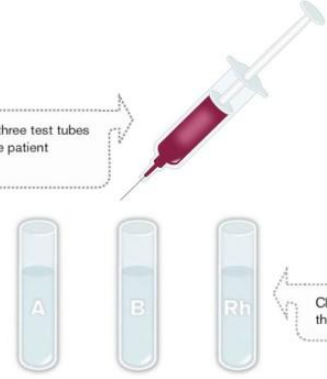
→ Proceed



**The Blood Typing game**

PATIENTS BLOOD TYPE ?  
SOUND  
MAIN MENU

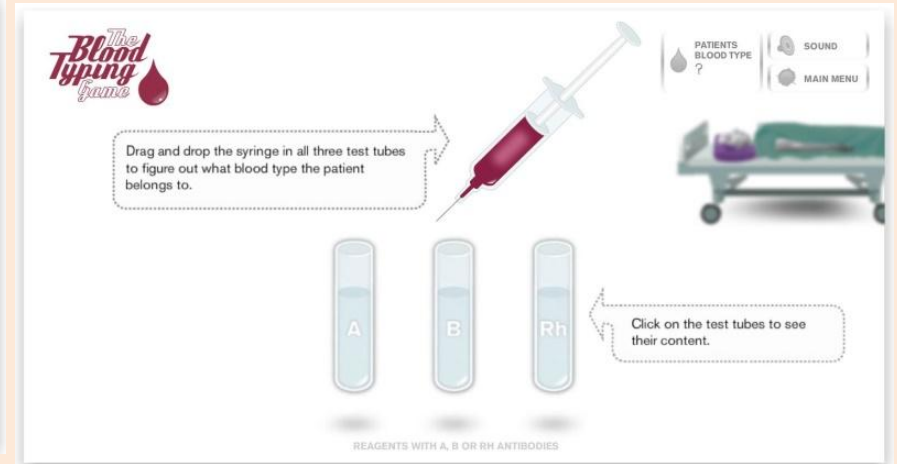
Drag and drop the syringe in all three test tubes to figure out what blood type the patient belongs to.



Click on the test tubes to see their content.

REAGENTS WITH A, B OR RH ANTIBODIES

# Vote – Blood Typing game



Is this an instance of effective integration of technology?

1) Yes 2) No



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# Educational games



# Analyzing computer games

Games contain:

Activity

Context

Rules

Competition elements

levels, points

People like games because:

Responsive

Interactive

Engaging

Fun

# What makes an educational game effective?



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Each one say one, based on your votes



# Examine evidence: Engagement, Learning

META-STUDIES: Review 300+ studies on games –

Engagement – HIGH; Learning - MIXED

*“Some games provide effective instruction for some tasks some of the time, but these results may not be generalizable to other games”*

*“...need to balance motivational elements with learning processes”*



# Takeaway



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Align game goal to learning goal

Make learning essential to game success



# How to effectively integrate tech for learning

- What is the learning goal?
  - Avoid meaningless goals like “Teacher should use more of the new tech”
  - Avoid generic goals “Students should improve understanding”,
  - Be specific, for ex “students should determine blood type of patients”
- What is the affordance of the technology?
  - Determine what it *really* provides towards the above goal
- What should students do beyond watch, listen, push buttons?
  - vote, make predictions, draw concept maps, solve problem – using tech



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# How to select “good quality” technology-based resources?

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Begin lobe here

# Final thoughts



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# Thank you

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