Projective Geometry

for the Liberal Arts Mathematics Class

DONNA A. DIETZ

Projective Geometry....

Not just for Math Majors anymore!

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Not just for Math Majors anymore!

ages 5 - 115

The Spot-it Deck:

55 Cards, each with 8 symbols.
Any set of two cards has exactly one symbol in common.

On the next slide, I will show two *Spot it!* cards.
Find the common symbol.


OK

Learning Objectives:

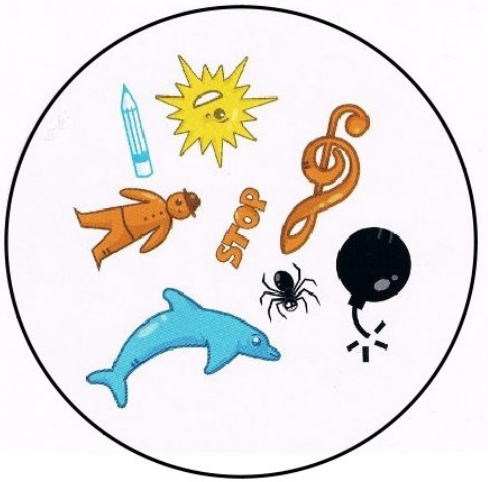
(why Mathematicians/teachers like it)

- Working with Finite Geometries (point/line axiomatic systems)
- Deeper understanding of modular arithmetic
- Probability
- Combinatorics
- Finite Projective Planes / Affine Planes
- Duality
- Axioms
- Single/Group problem solving skills

What the students like:

- Hands on! (scissors, drawing, arranging things)
- On-line apps to use in and out of classroom
- It is a game.
- Productive group work
- Visually appealing
- Formulas come later, after they make sense.
- This topic is brand new to nearly everyone, so nobody feels like “the only one” who hasn't done this before.

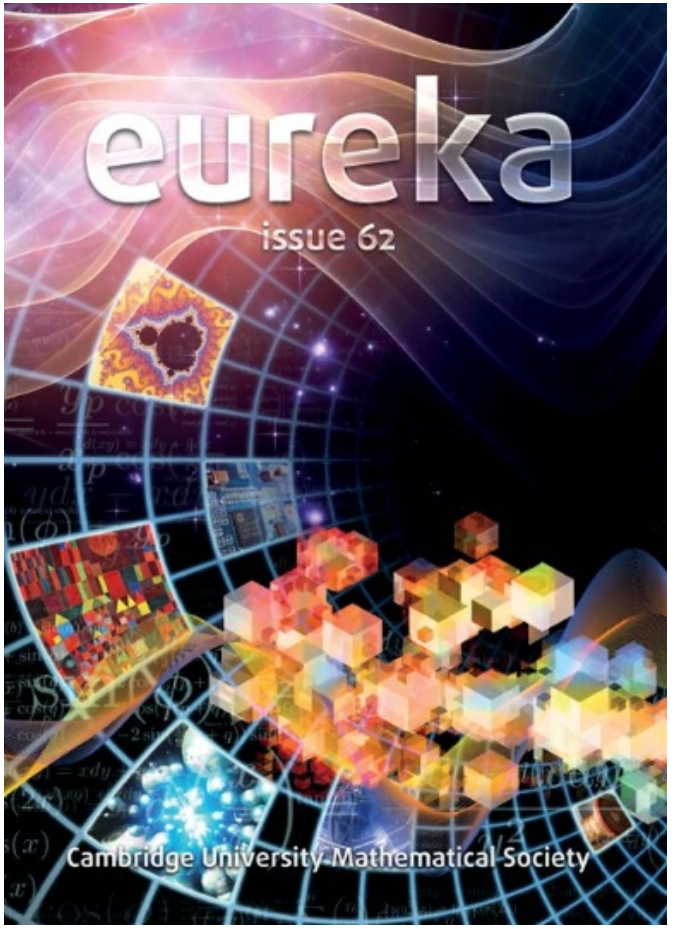

OK


STOP


ART


ART
OK
STOP

Please Read My Upcoming Paper....



- Cambridge Undergraduate Mathematics Journal.
- Since 1939, not quite every year....
- Paul Erdos, Martin Gardner, John Conway, Hardy, Penrose... and soon... ME!

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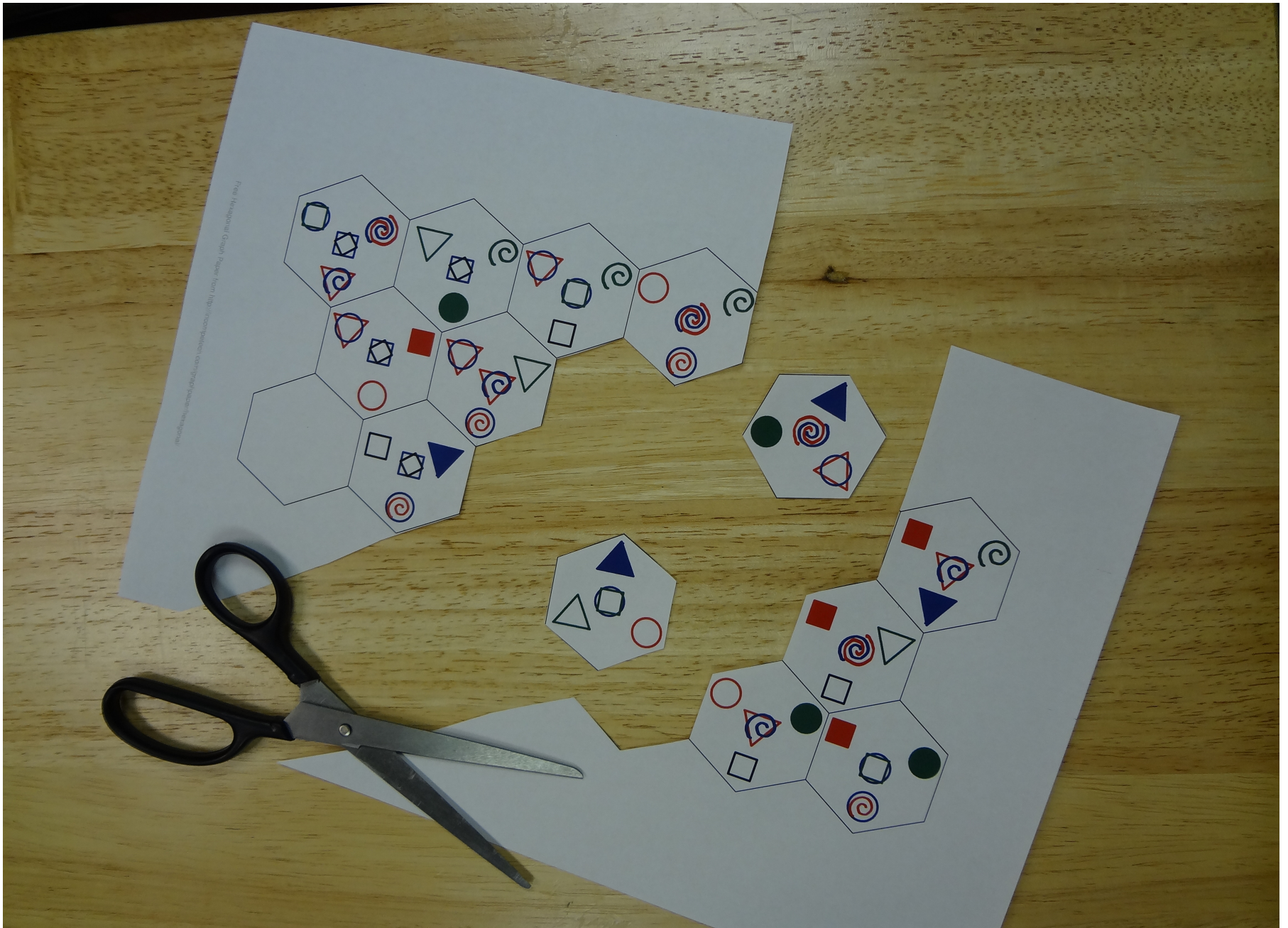
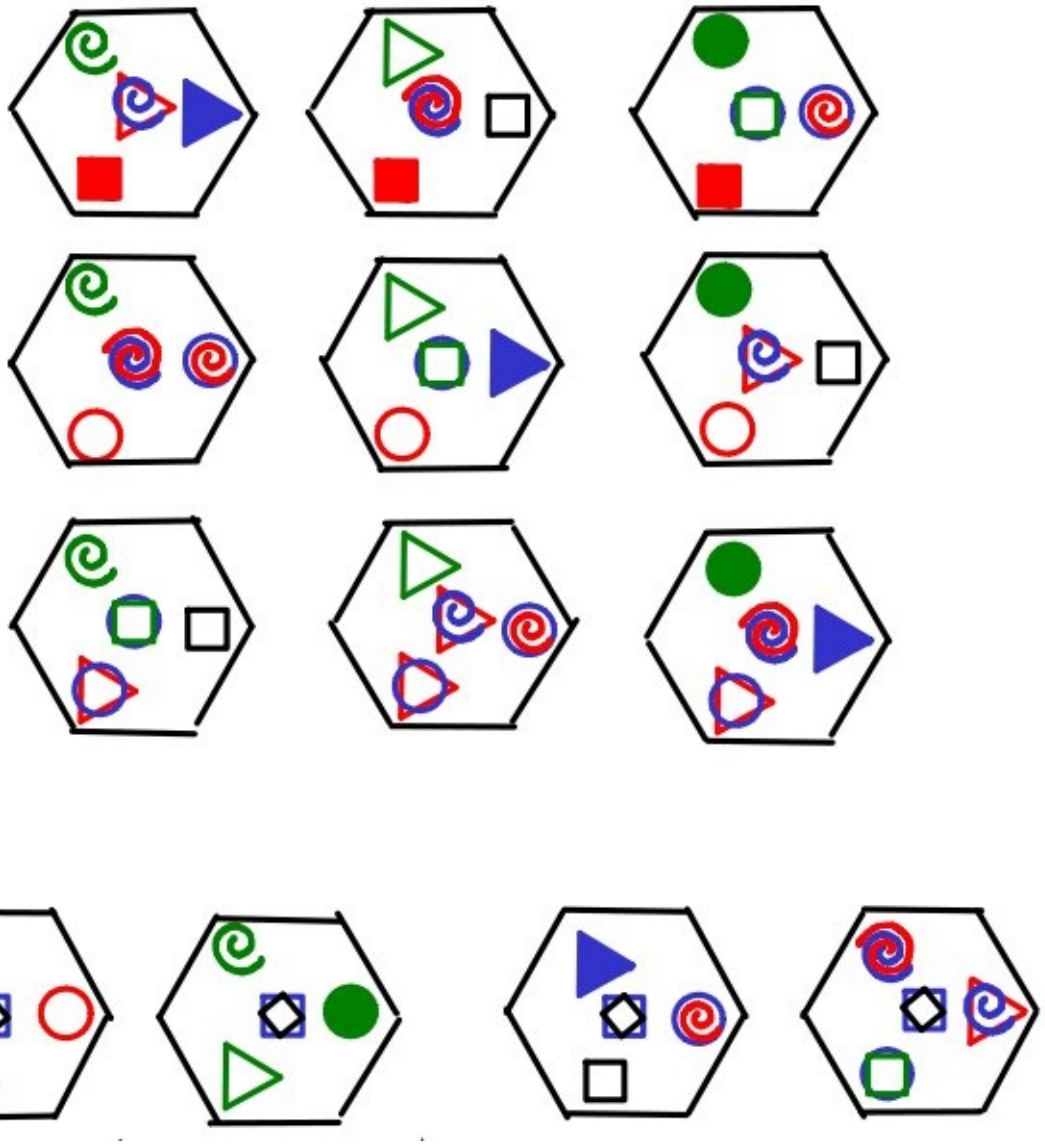
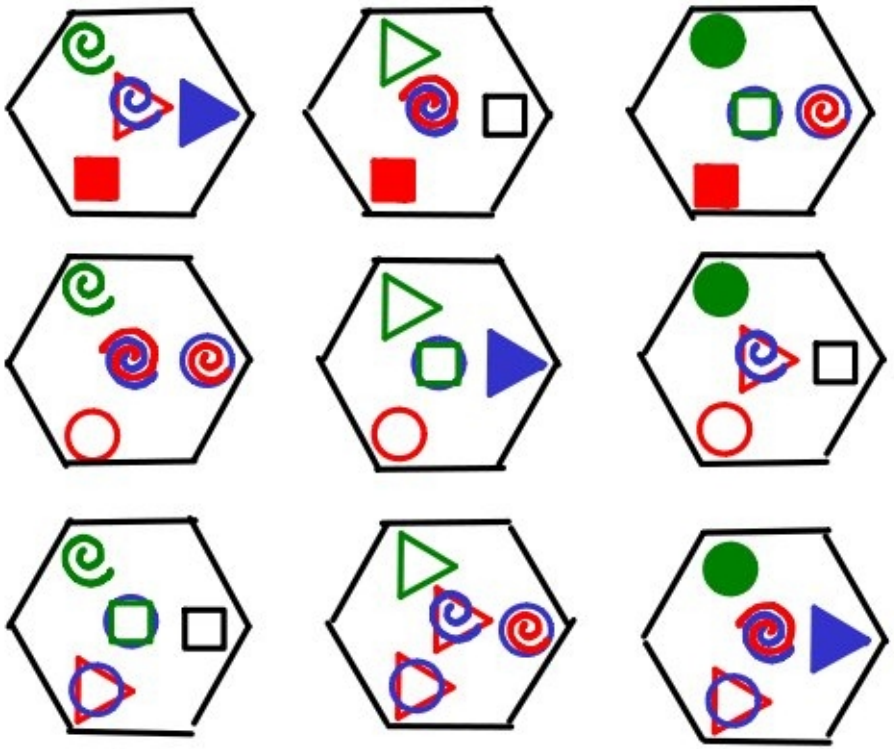
STOP

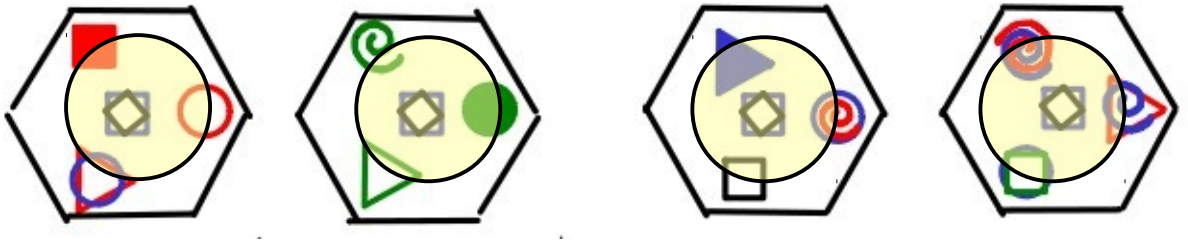

Spot it!
H
V
1
-1
2
-2
3
-3

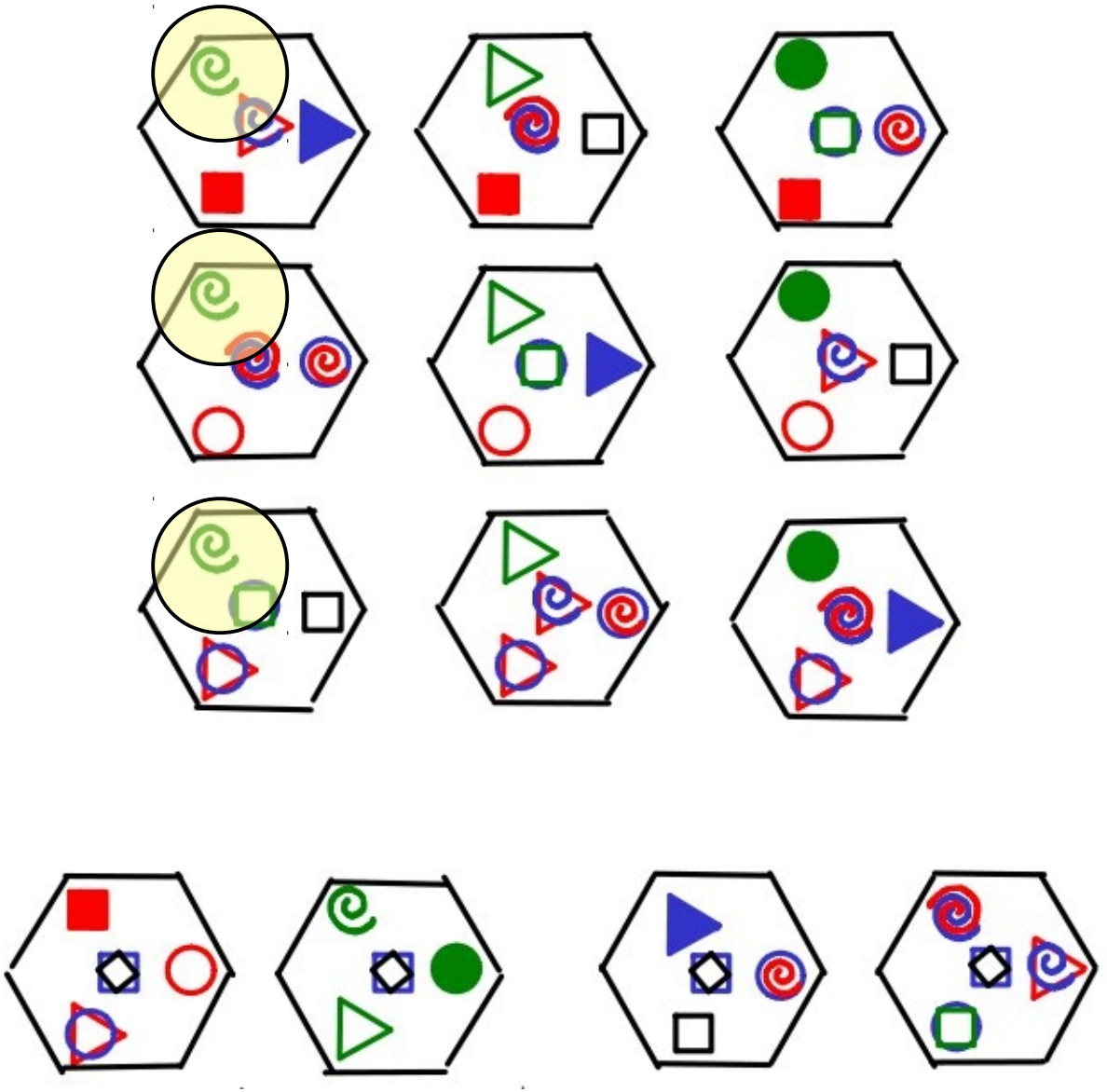
Classroom Activity

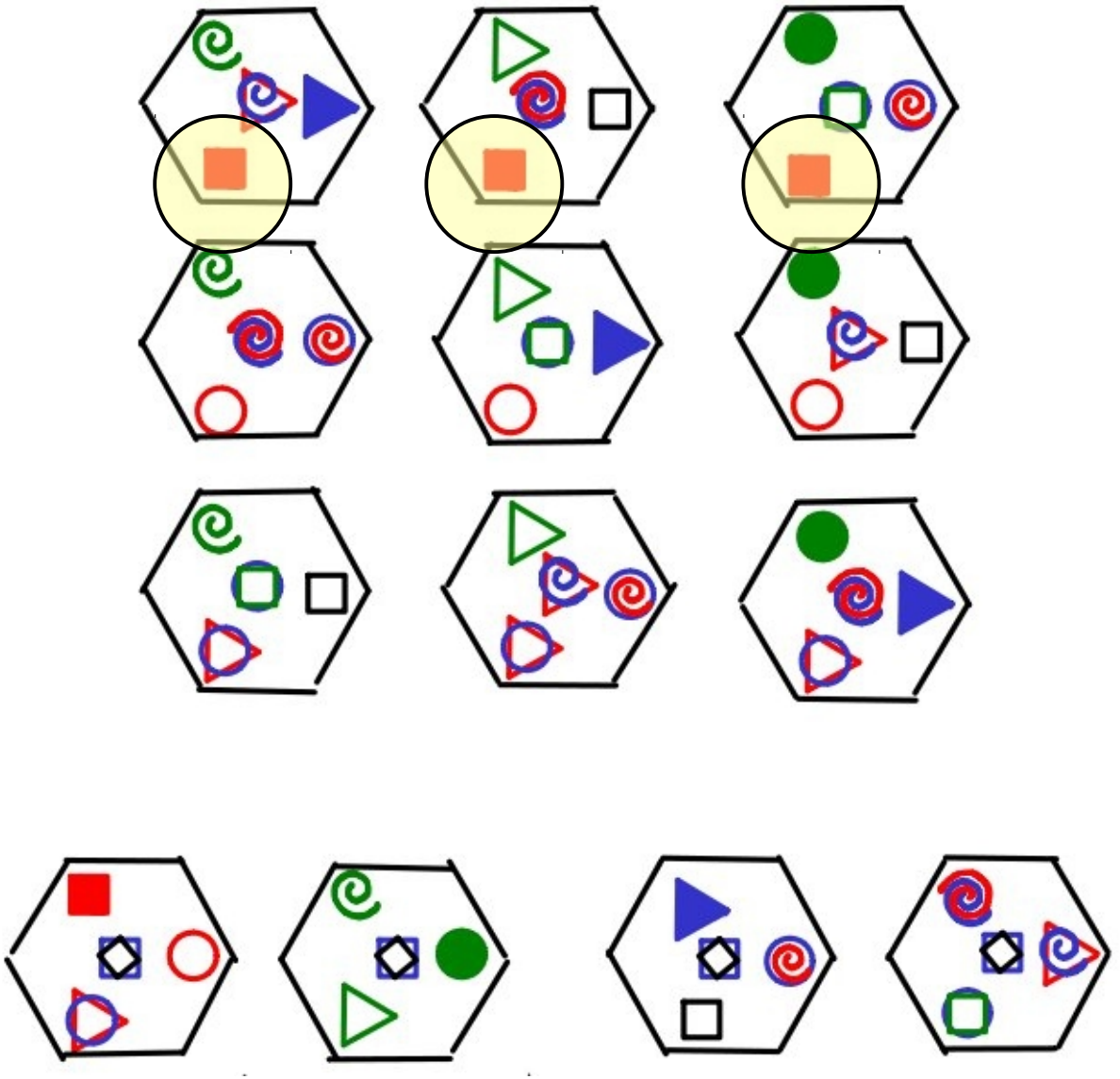


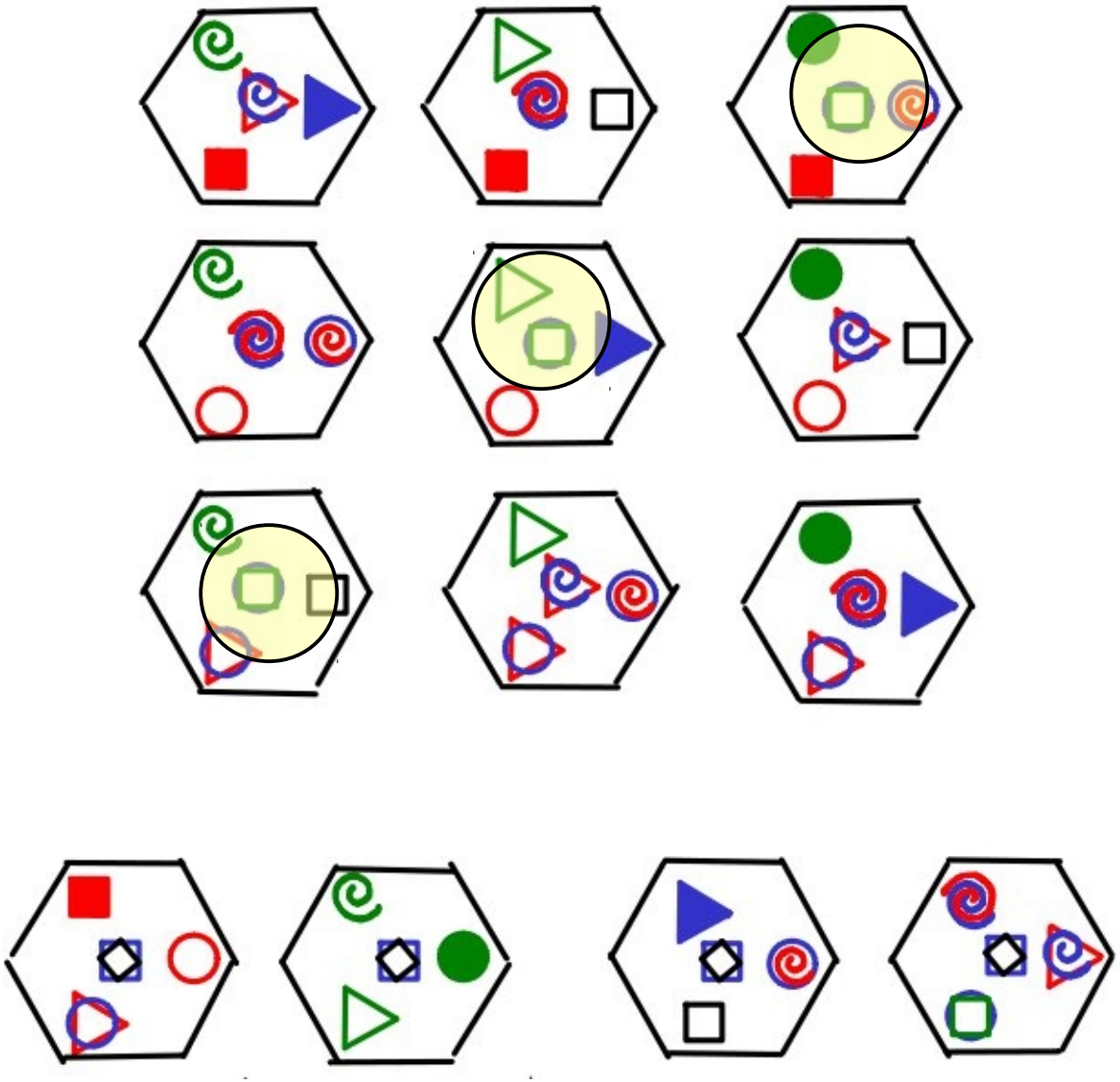


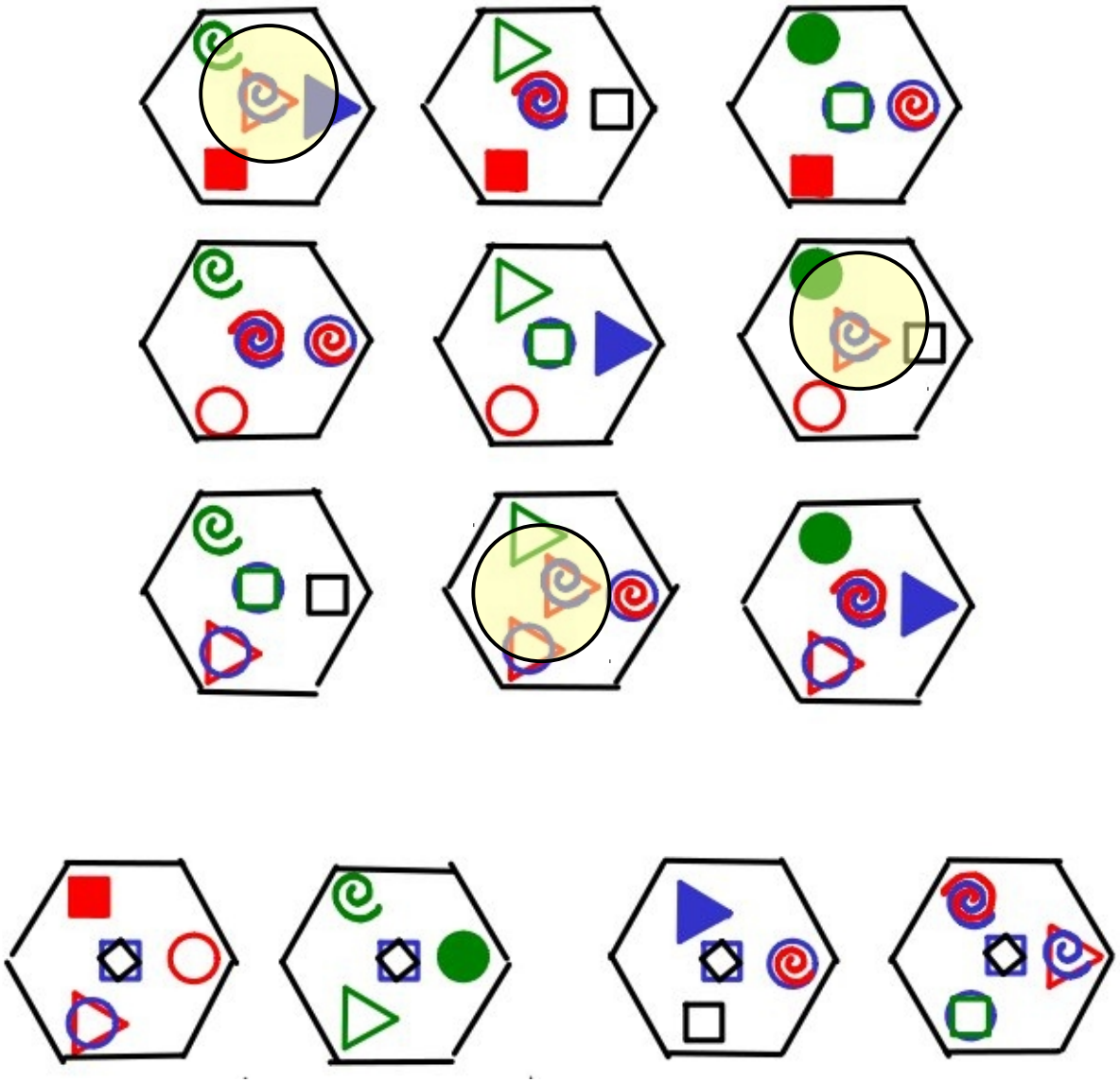


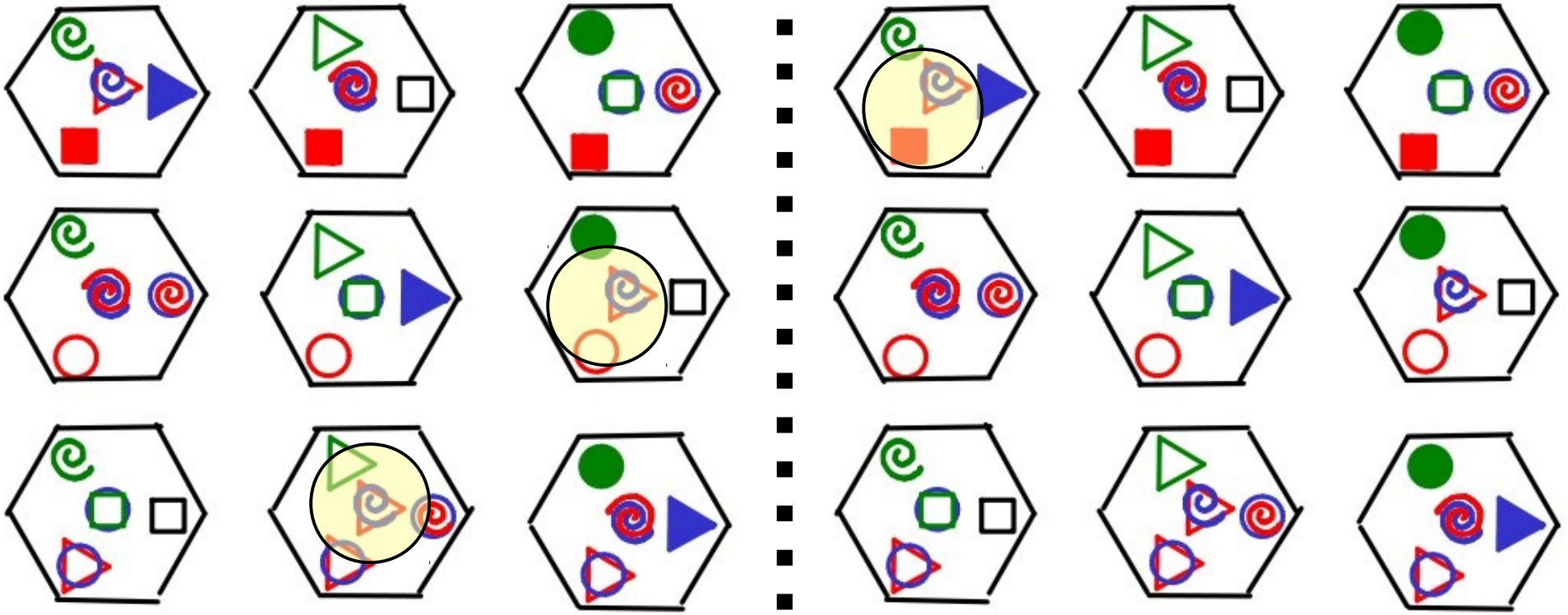












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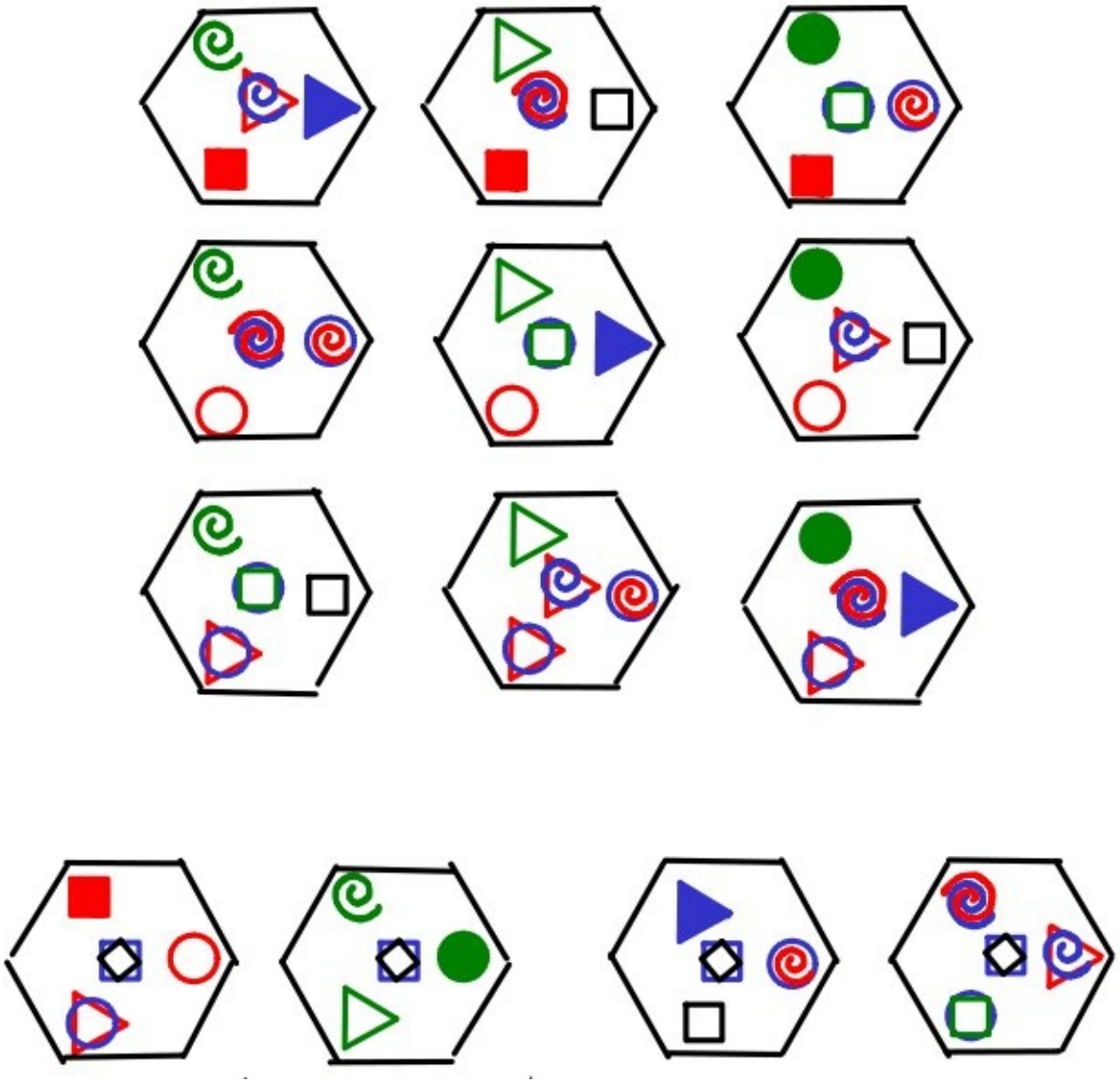
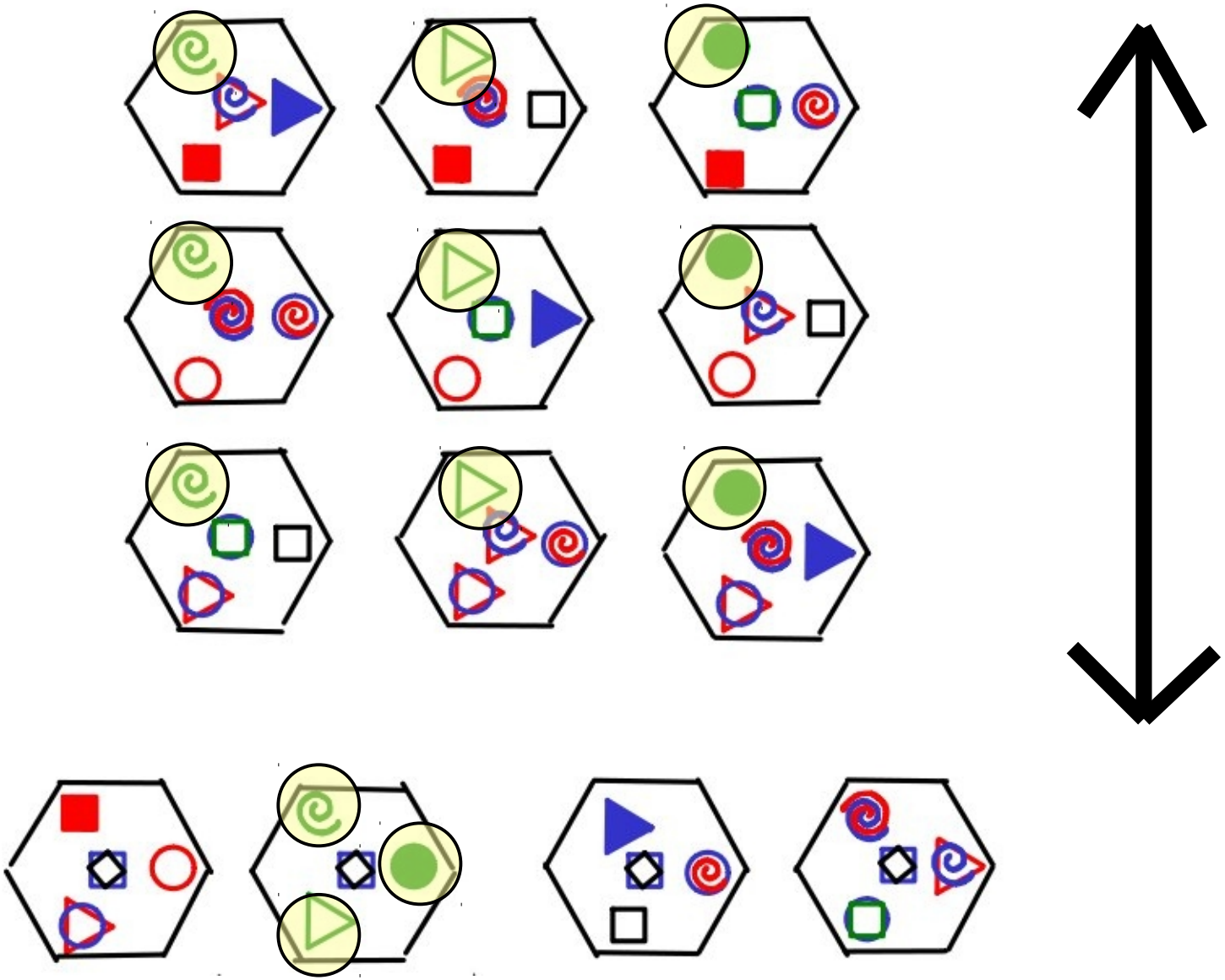
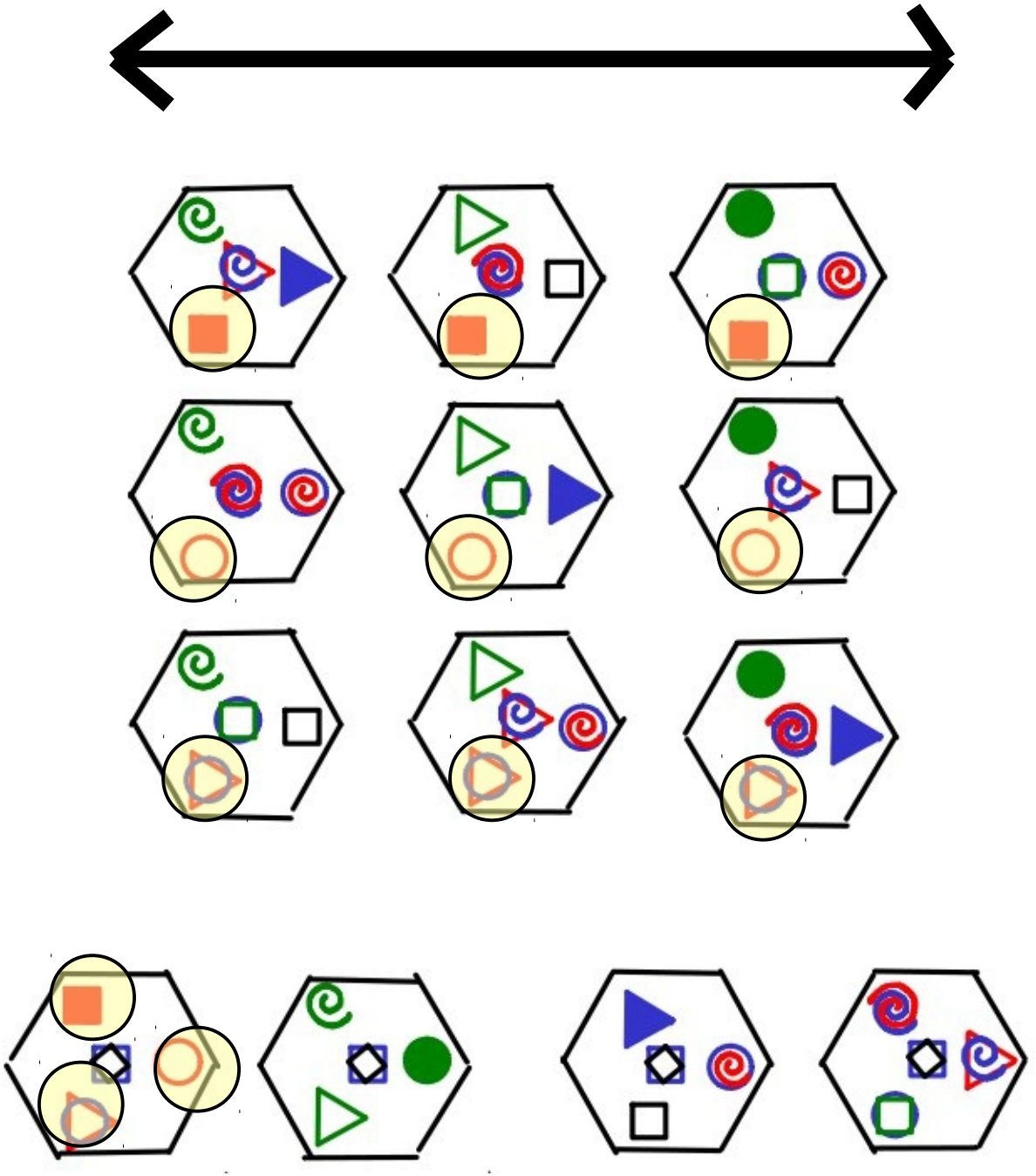
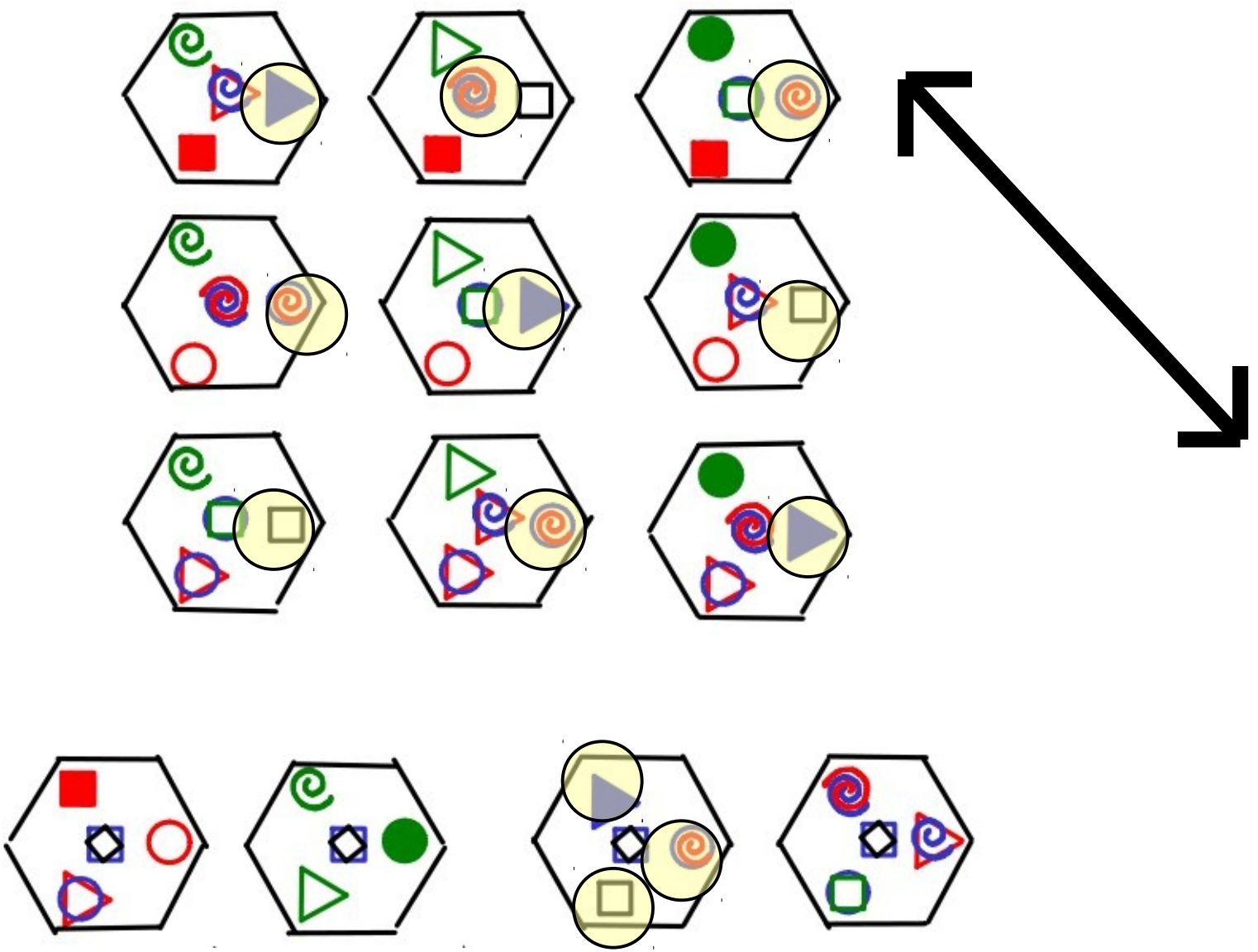
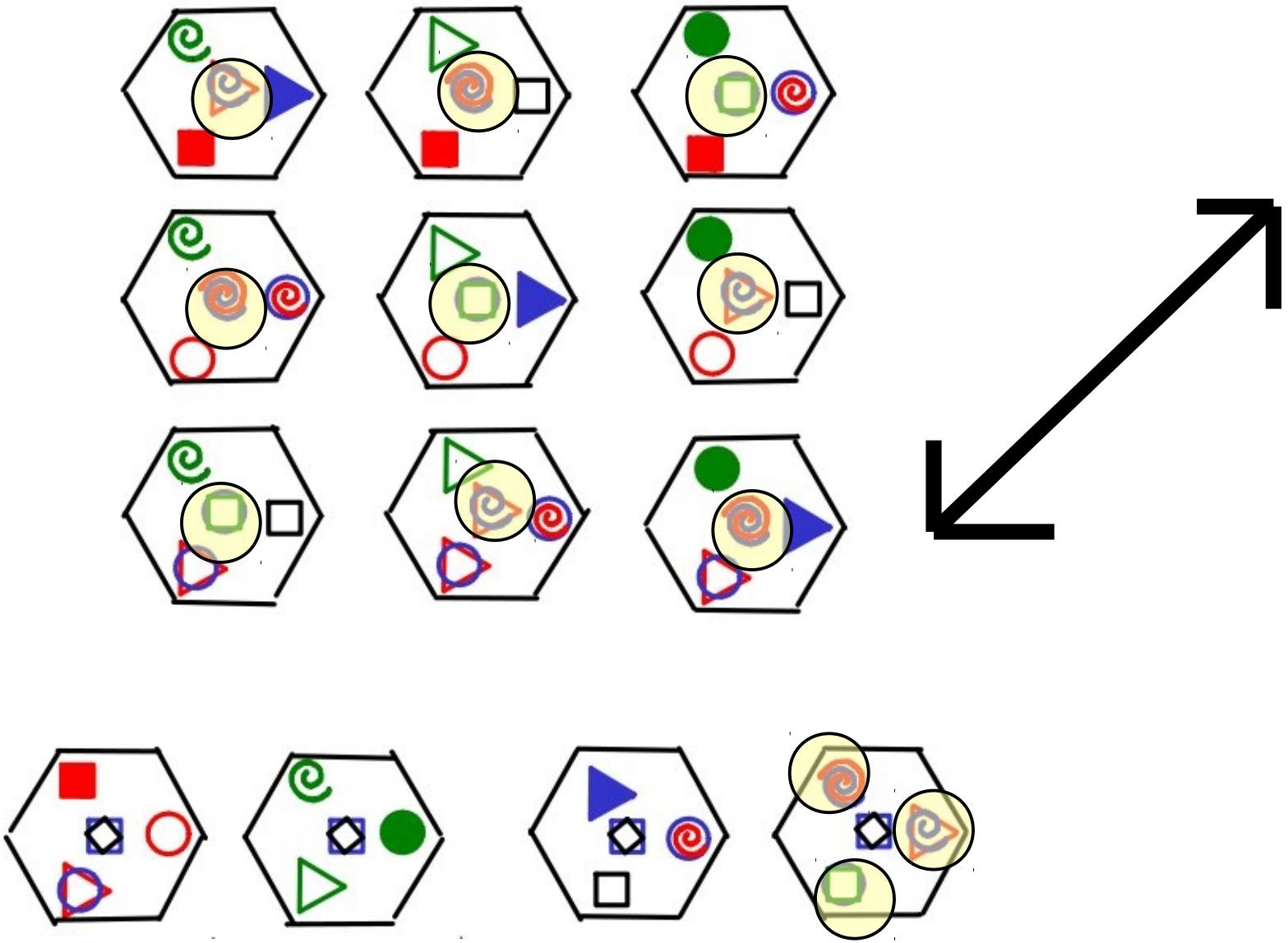


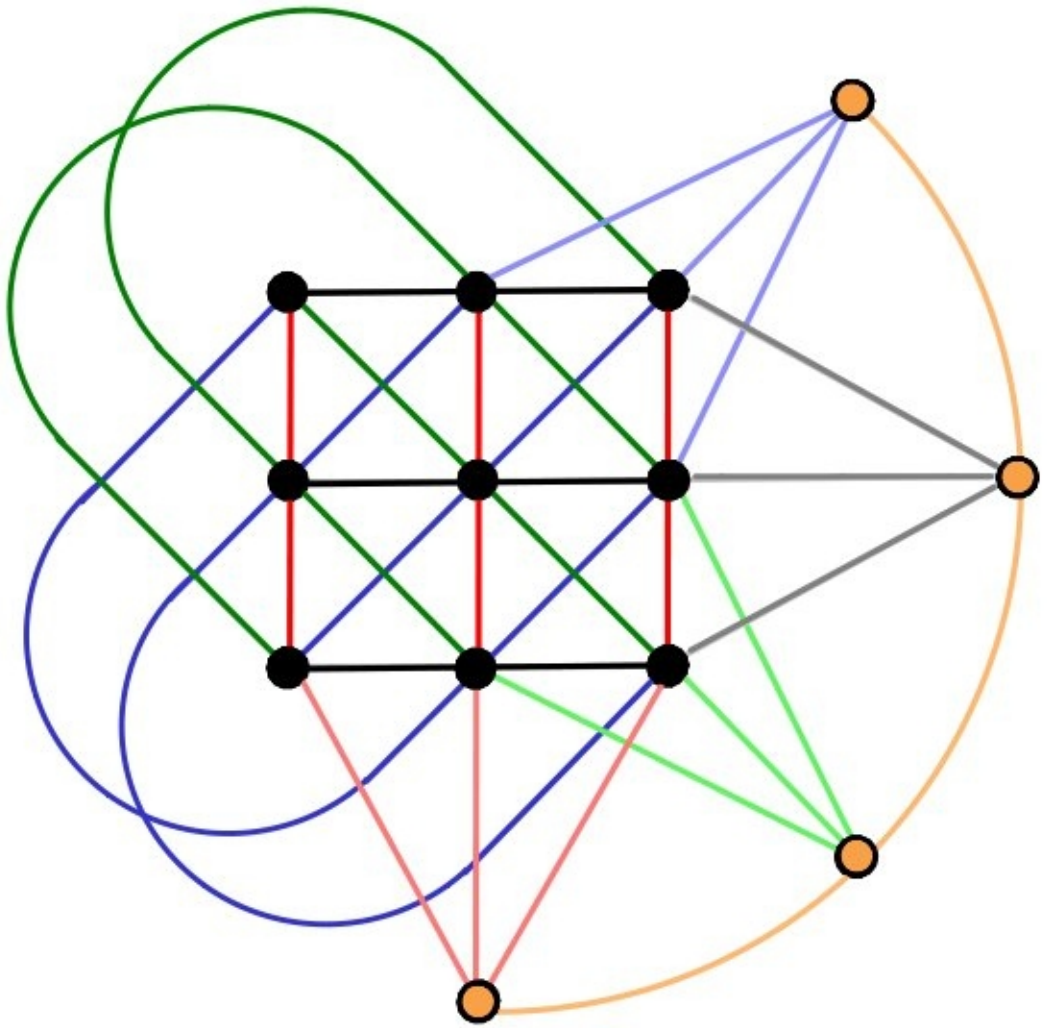


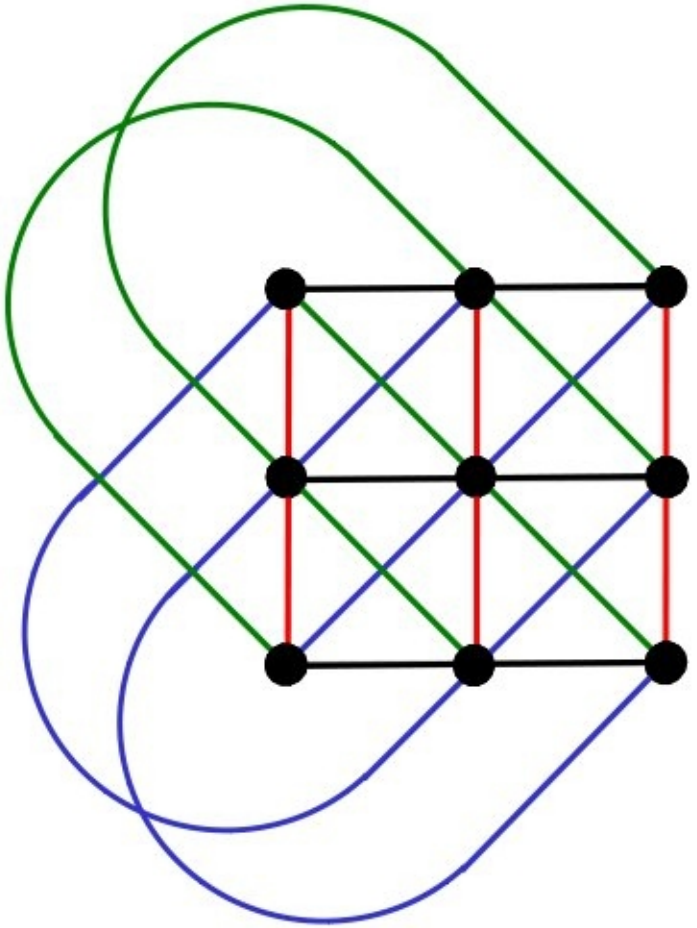






n=3 Projective Plane & Affine Plane





Biggest Challenges:

- Problem is too small to properly assess understanding in students; they appear to understand it better than they do.
- Explaining the torus/wrapping for diagonals.
- Convincing them that there are two families of diagonals, rather than just one.
- They need feedback while studying.
  - This is why I wrote the Java/Javascript apps.

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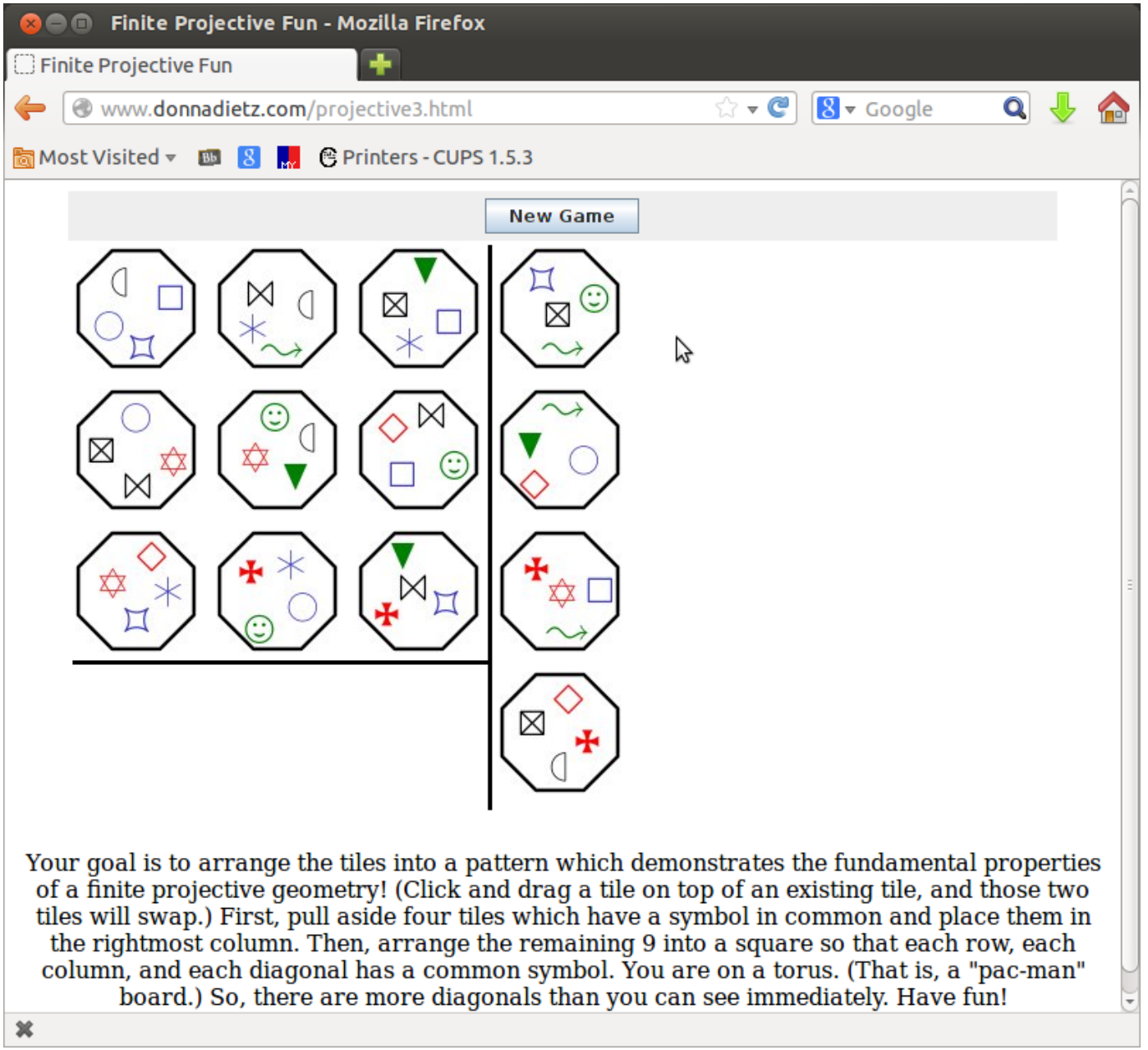

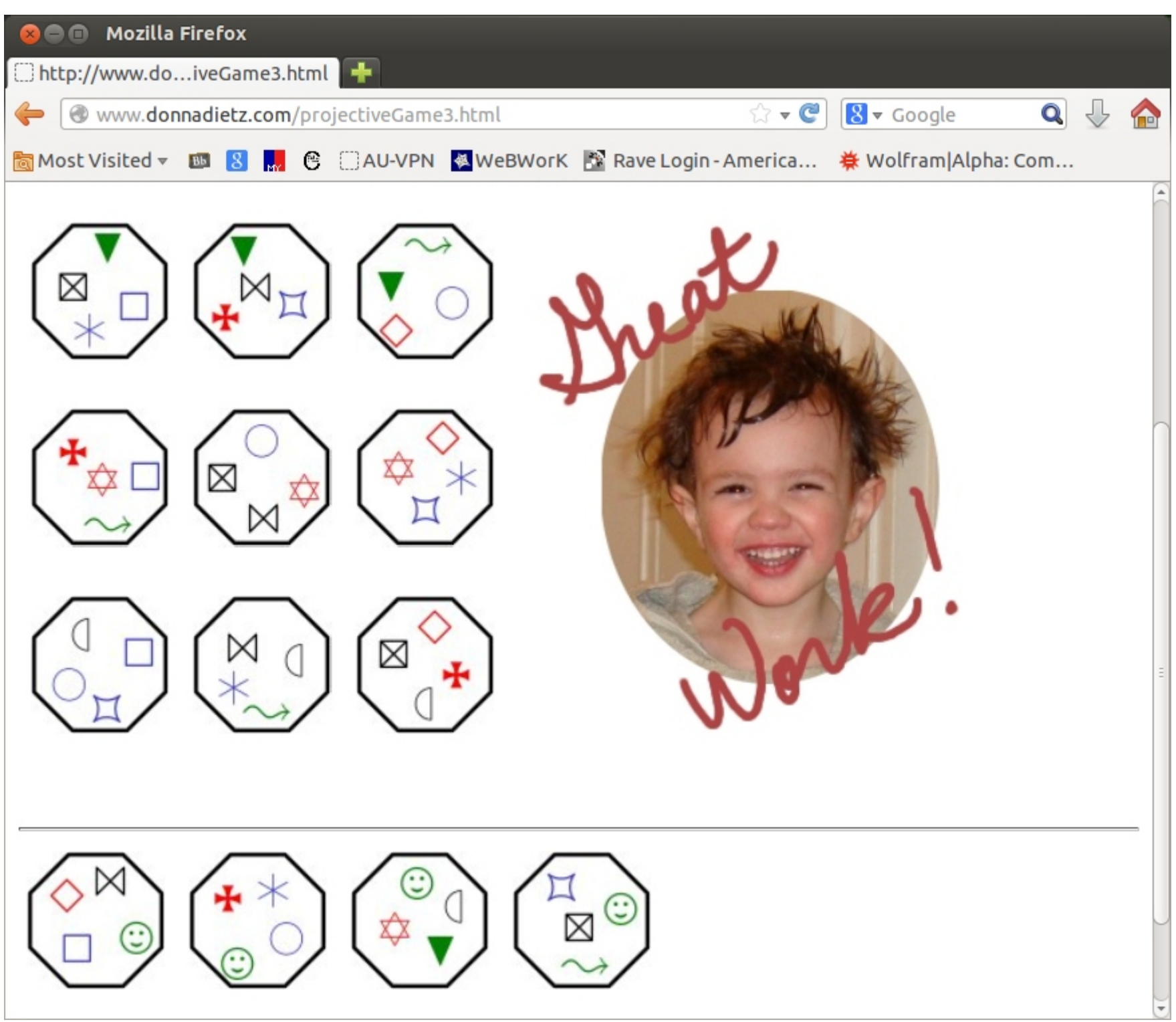
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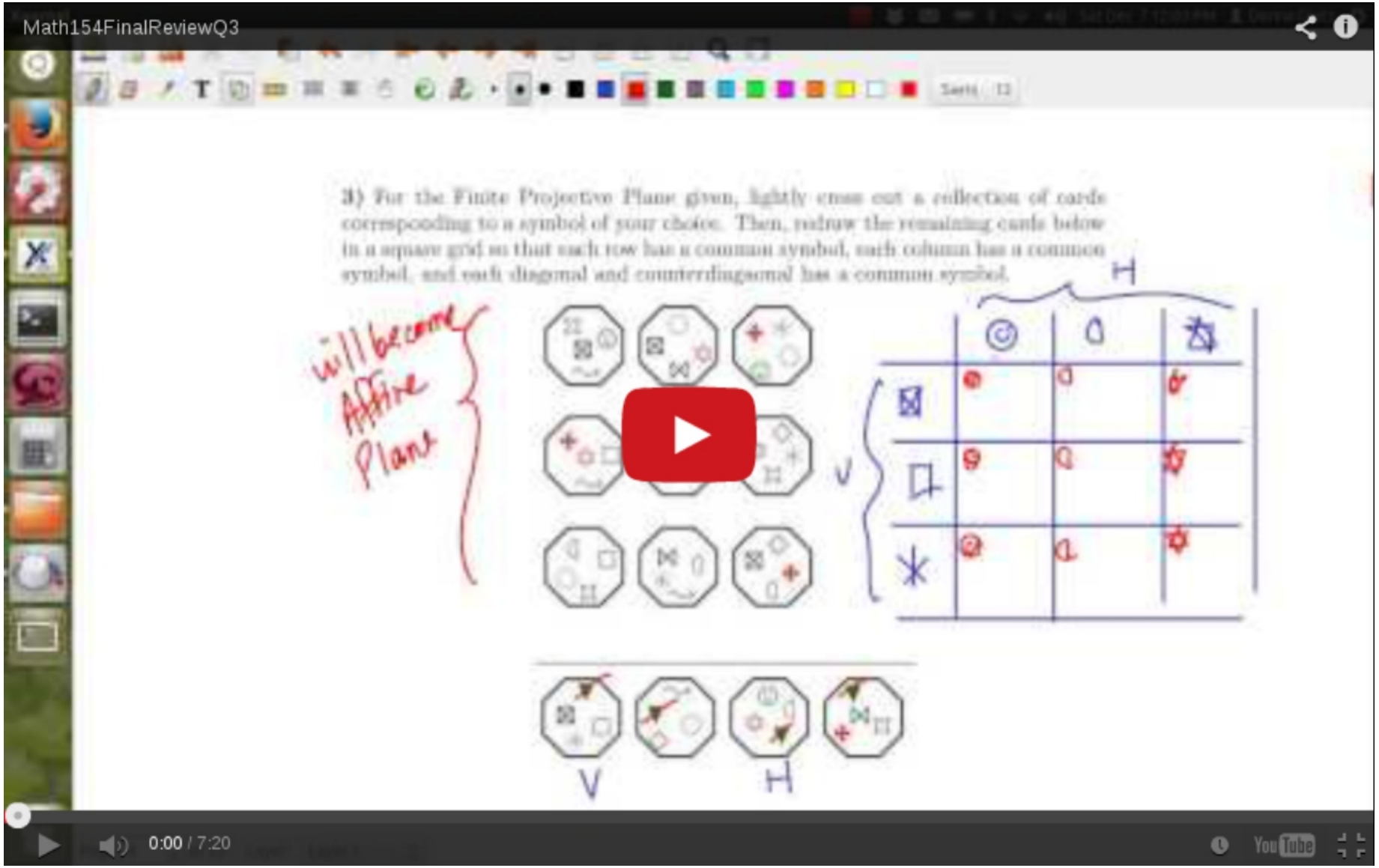
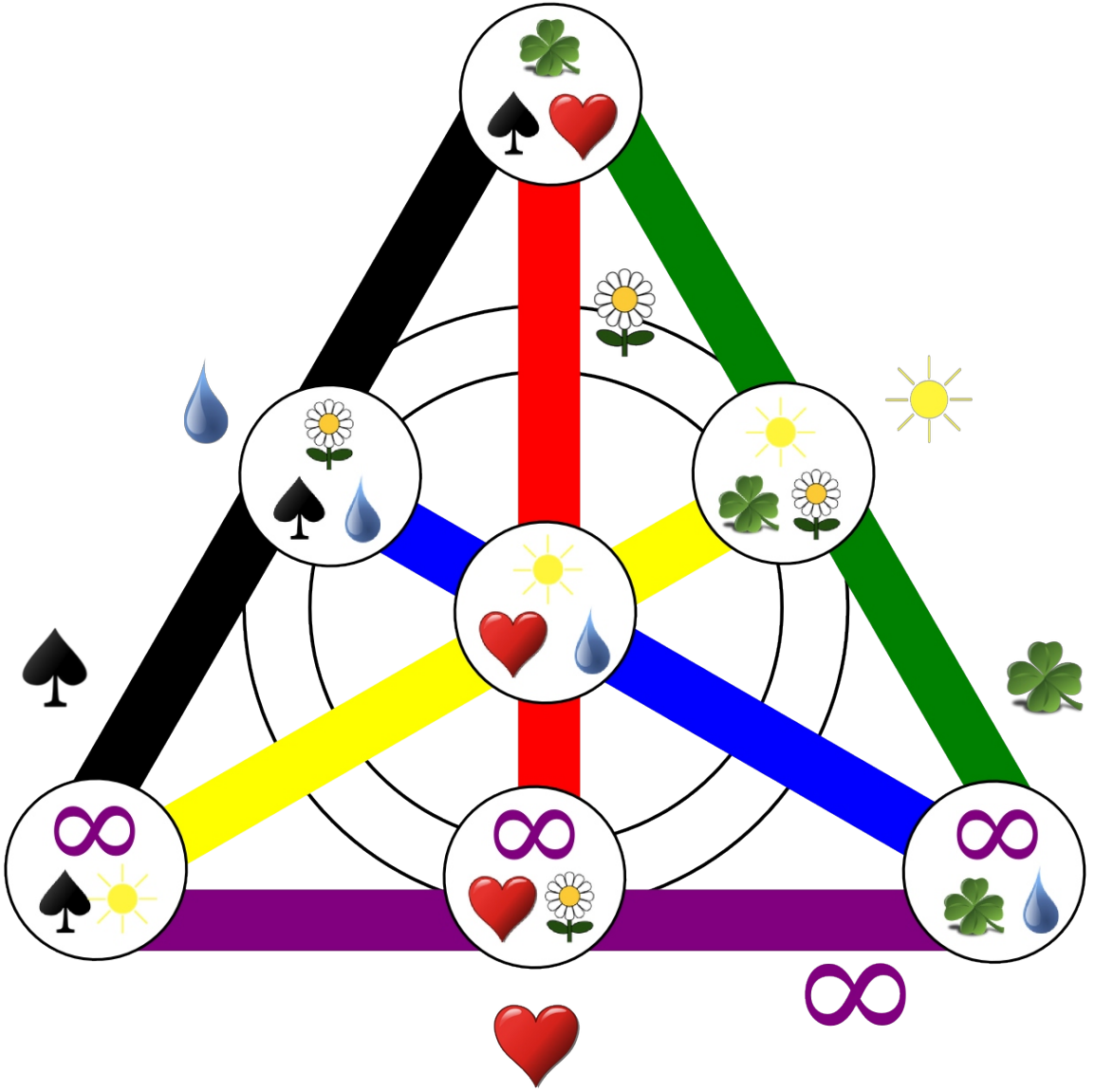
Wolfram|Alpha: Com…
Great
Work!

YouTube explanation



Maxime Bourrigan, *Dobble et la geometrie finie.*
Images de Mathematiques, CNRS 2011




Spot it!
blue orange
Spot it!
blue orange
Spot it!
Spot it!


Dobble
Dobble

The Fano Plane is the n=2
Finite Projective Plane

Children's Spot-it! is the n=5
Finite Projective Plane

Spot-it! (Regular) is the n=7
Finite Projective Plane


Spot it Jr!
Spot it Jr!
Spot it Jr!
Educational Game for 2 to 6 Players
For Players Ages 3 and Up
Spot it!
Alphabet
blue orange
Educational Game for 2 to 6 Players
Spot it!
Alphabet
For Players Ages 3 and Up

Main Points:

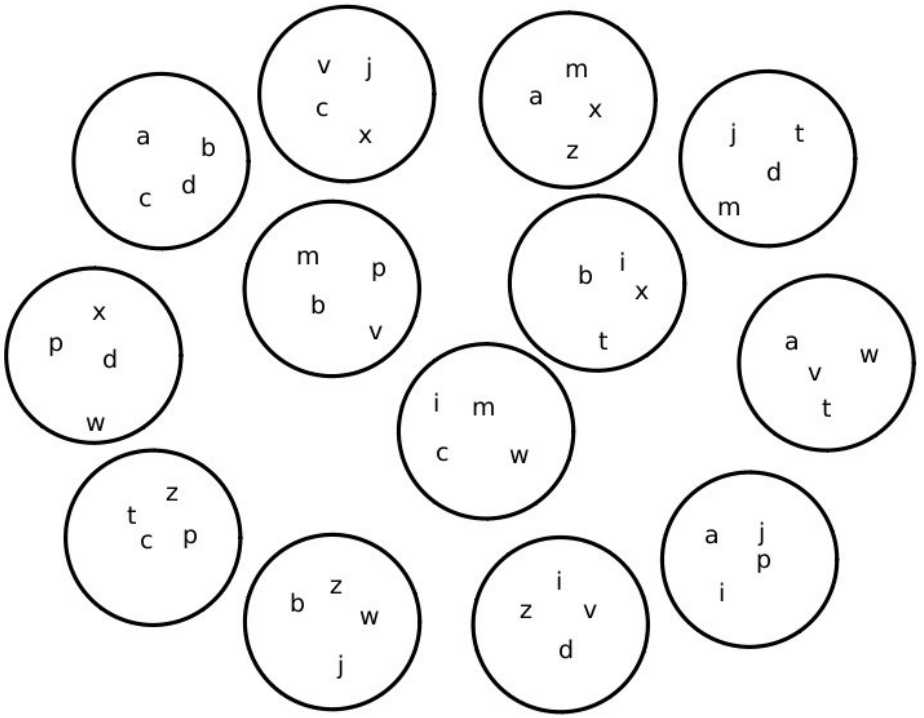
- *n* is prime
- Any arbitrary pair of cards has exactly one common symbol.
- Any arbitrary pair of symbols is present on exactly one card.

For n=3:

Exam Questions

Test Questions:

Lightly cross out four cards. Redraw the remaining cards in a 3x3 grid representing an affine plane.



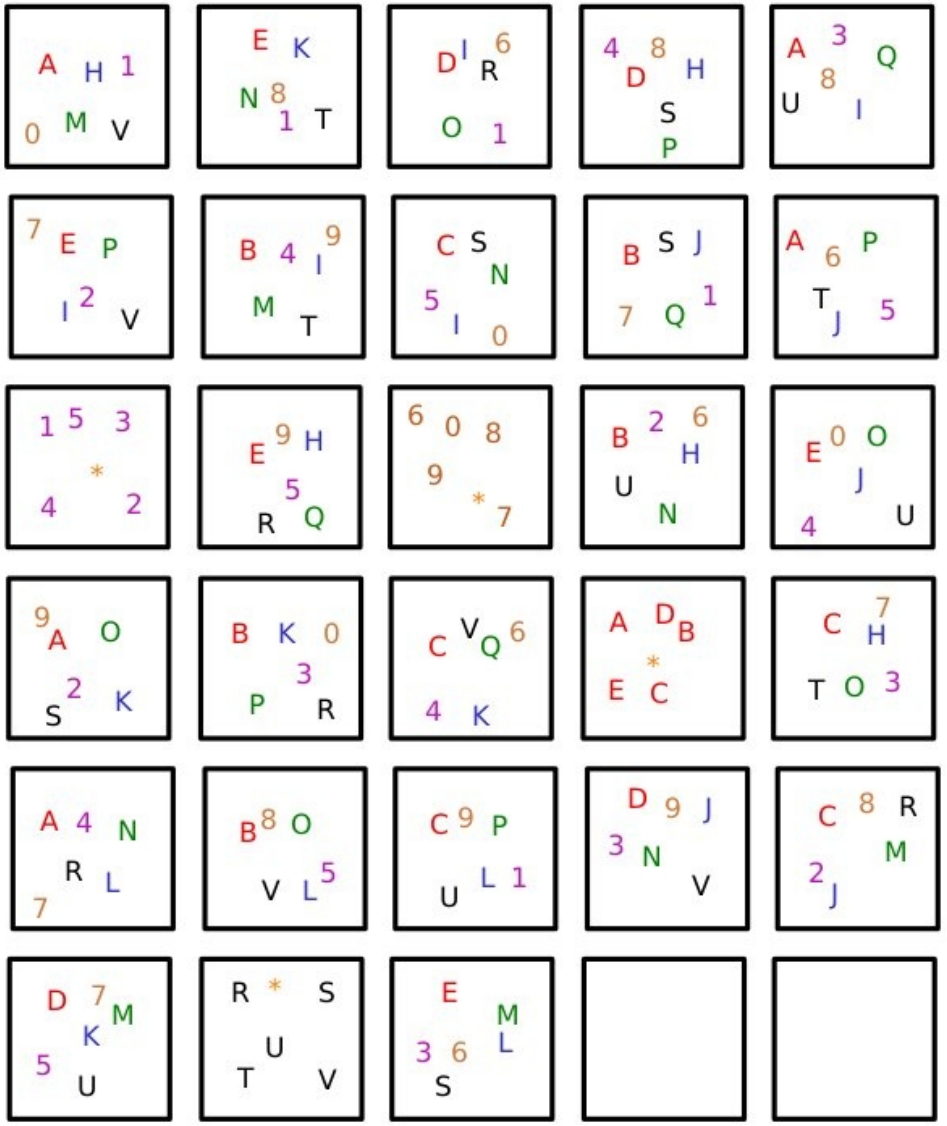
Results:

- Great problem! They liked it!
- You need to do one like in in class.
- It suffices to set rows/columns (diagonals free).
- Biggest problem: convincing students to use the cards you have provided. (They prefer to just draw their own new set of cards, which would be a good, but different, problem.)

For n=5:

Classroom Activities
Javascript App (which I wrote)
Exam Questions

Classroom Activity:
Find the missing cards

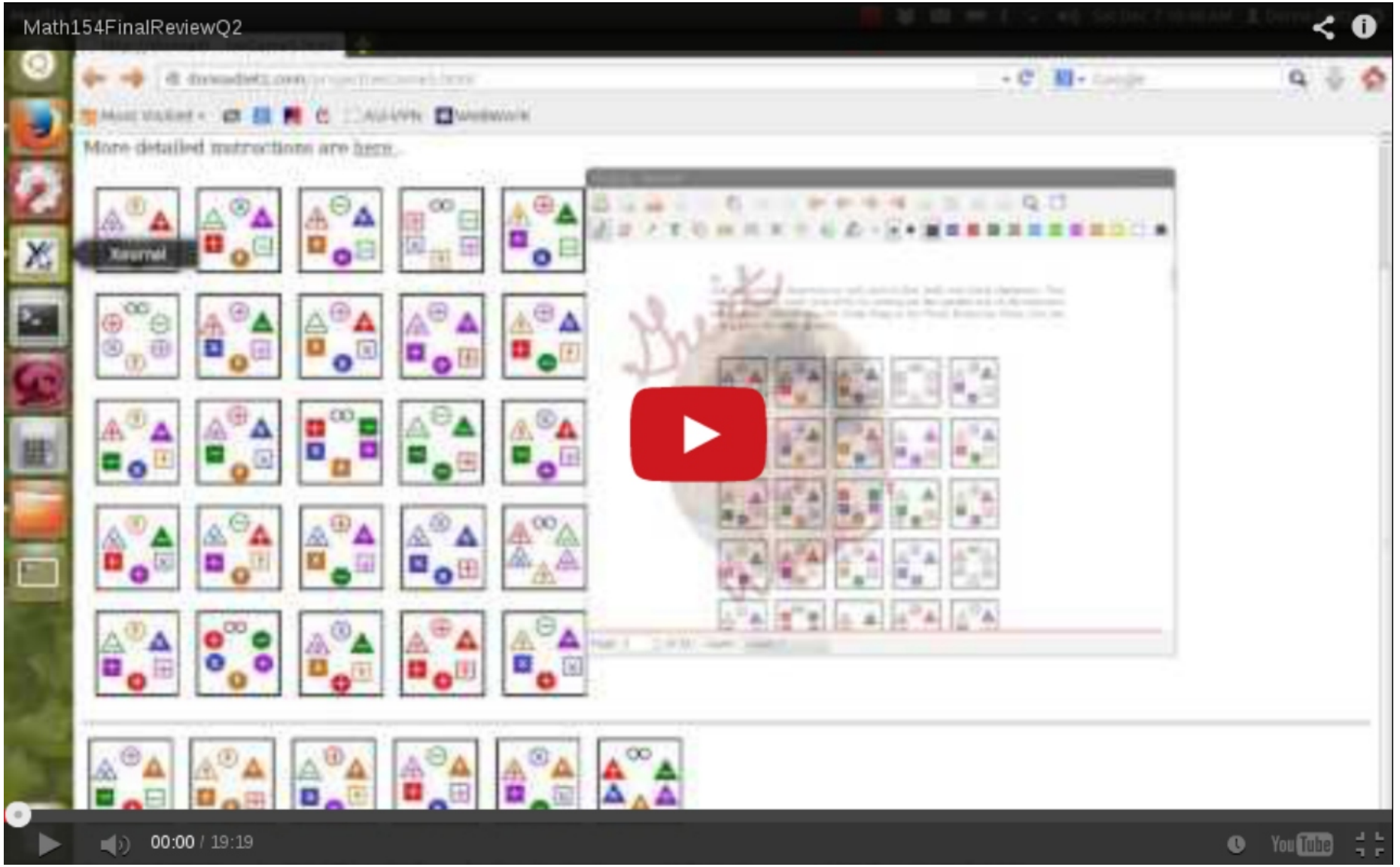


What is missing? (Three cards.)
They contain these symbols:
* * D H I J K L L M N O P Q Q T 2 0

Results:

- Good for group-work
- Still struggling with the two diagonal families not being the same, and now the m=2 , m=-2 families also.
- Drives home fact that each pair of symbols must occur together exactly one time, and each pair of cards contains common symbol.
- n=5 Projective Plane complex enough to learn main concepts.
- Lends itself well to hints along the way.
  - “Which symbols are missing twice?”
  - “What if one symbol were missing three times?”

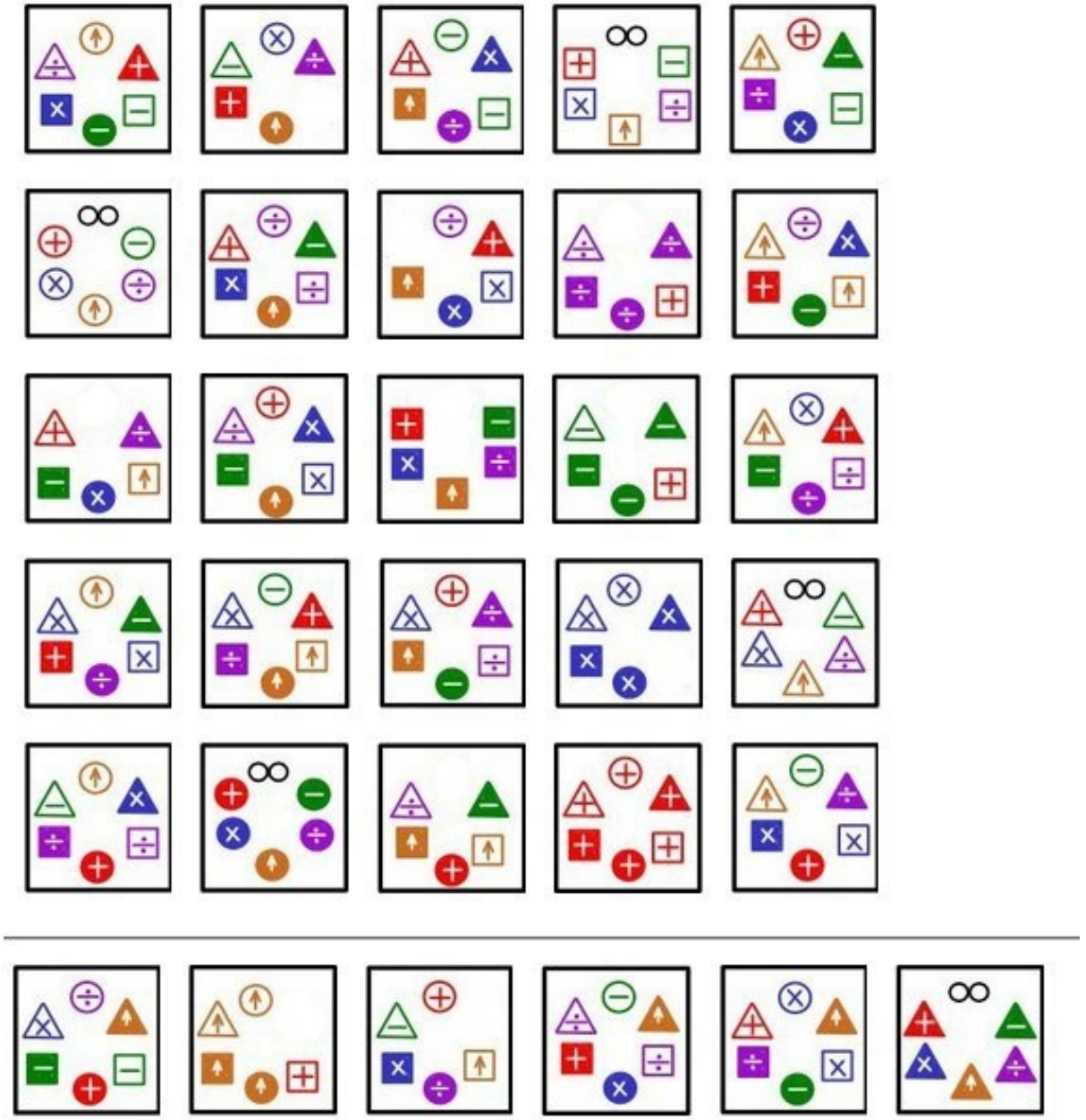
Javascript app and YouTube help



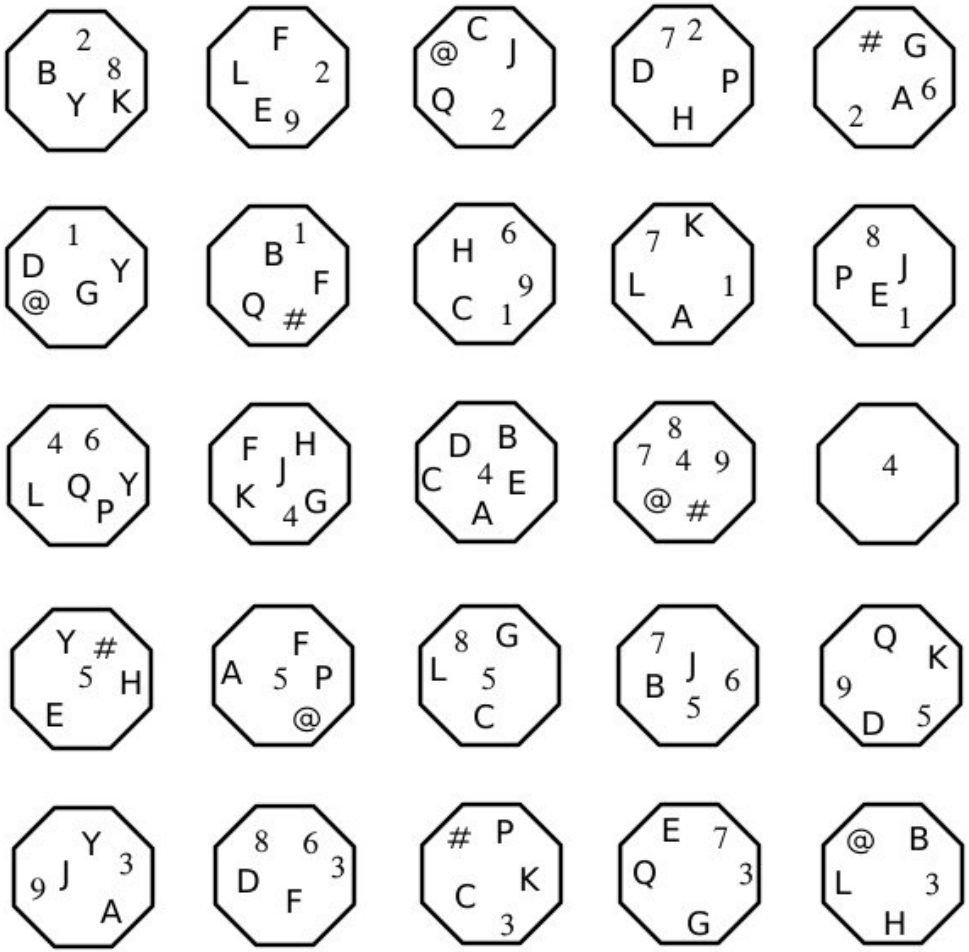
n=5 Exam Questions

- Sometimes given Affine Plane only
- Find missing symbols
- Find parallel families
- Find missing cards

Fill-in missing symbols:



Fill-in symbols and give parallel sets:



Results:

- Regular alignment of artwork is best, so missing symbols are obvious.
- Randomly removed symbols are easier to replace than entire lines.
- Students prefer having the infinity line present.

And Much Much More

15 minutes is not enough.

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Email me

Student responses:

- My students seemed to enjoy this unit.
- Anytime the scissors or glue come out, their math anxiety seems to drop and the go into fun mode. (Art can't be math, right?)
- My students nominated me for the CTRL Jack Child CTRL Teaching with Technology Award because I wrote these apps, so I guess that means they liked them. (And I even won the award.)

Center for Teaching, Research & Learning

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