Learning Geometry in the Dance Studio

MAA Special Session: Connecting Math to the Liberal Arts

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Charleston, SC

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- **Christina Soriano**
  (Theatre/Dance Dept.)

Wake Forest University

Who we are

- *Christina Soriano:* modern dance choreographer/performer & professor,
  minimal math background
- *me:* researching 3-dim. geometry & topology,
  no dance background

- at new faculty dinner, she said "I'm thinking of choreographing a geometric piece this fall"
- Collaboration led to cross-disciplinary teaching past 2 semesters

Cross-disciplinary Teaching

Brought together
liberal arts math class &
intro. to modern dance class (fall)
dance composition class (spring)

They formed **Platonic solids** both in the math classroom & dance studio

They studied reflection properties of **ellipses**

Today's Outline

1. Goals
2. Fall 2006 `Trace of a Moving Point' dance
3. Some historical dance context
   (Laban & Schlemmer)
4. Our interdisciplinary pedagogical exercise
5. Evaluating impacts

1. Our Goals

For us

- Chart pedagogical exercise
  - applicable to numerous courses/settings
- Motivate others to think spatially
- Geometry influencing creative process
- Demonstrate interconnectedness of math & of motion

1. Our Goals

For students

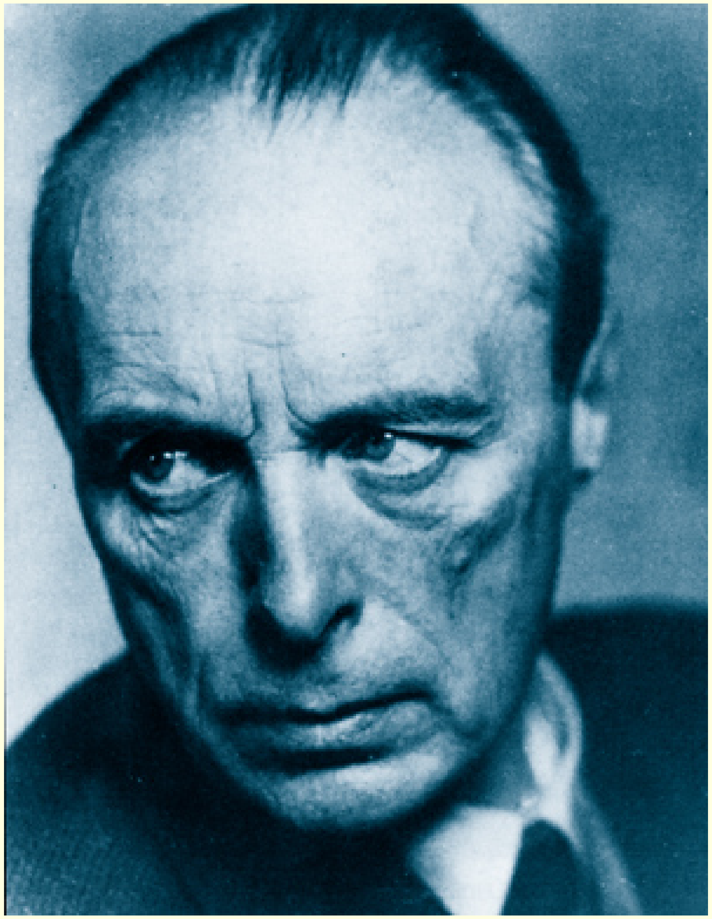
- Experiential learning
- Increase spatial reasoning & memory
- Interconnectedness of math & arts
- Understand duality, in the large
- Producing math & producing dance are journeys
- [math students] greater appreciation of regularity
- [dance students] introduce geometric ideas into future choreography

2. Soriano's geometry piece

'Trace of a Moving Point' (fall 2006)

- Seeks to represent human form as point moving along *line* & later on *circle*
- Geometric input
  - brainstorming sessions
    Pascal's triangle, triangular numbers, fractals, Cantor set, Flatland, positive/negative curvature & triangles
  - Arranging **14** dancers
  - Rehearsal visits

3. Dance history



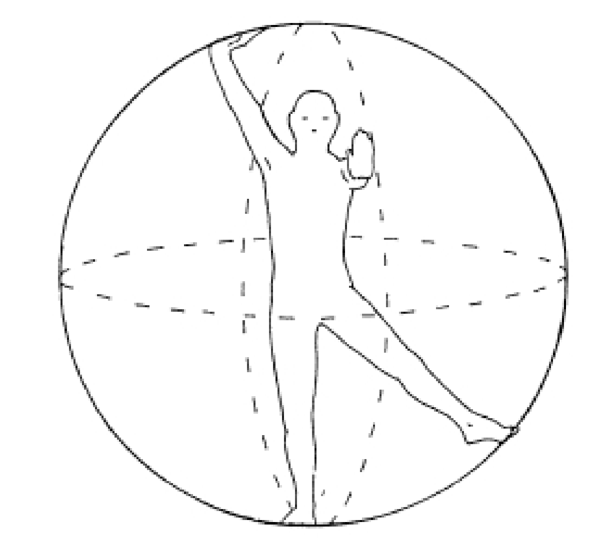
Rudolph von Laban
(1879-1958)

introduced vector notation for dance motions
- energy, time, space

Strongly connected Euclidean geometry & Platonic solids with canon of dance

Laban & Platonic Solids

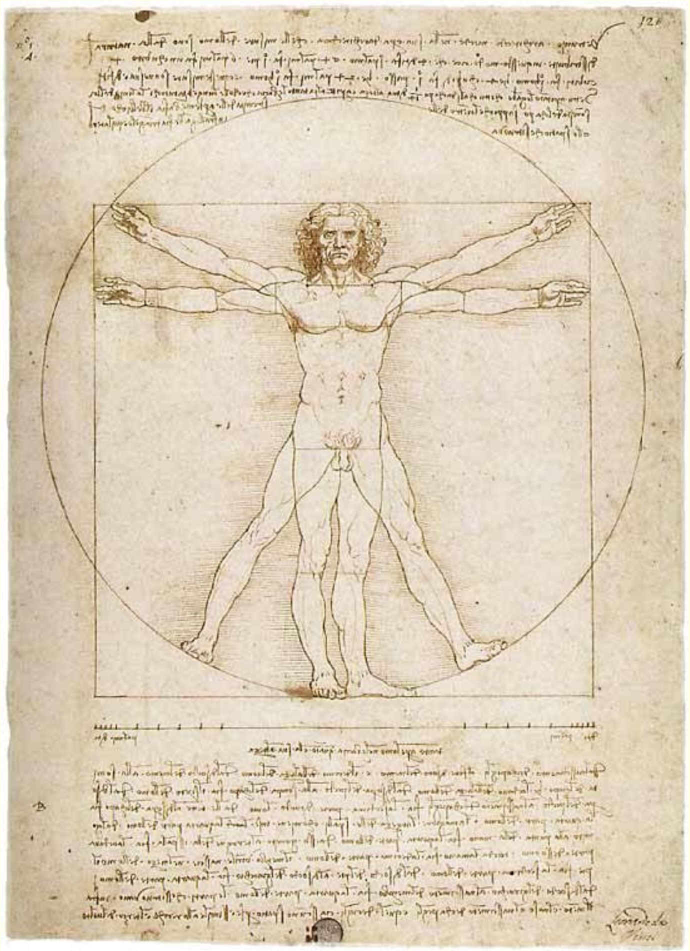
Laban introduced idea of the **kinesphere**, allowable motions



- *primary* – up/down
- *secondary* – left/right
- *tertiary* – forward/backward

- Within kinesphere, Laban was fascinated by Platonic solids, particularly
  cube, tetrahedron, & icosahedron,
  for detailing motion space

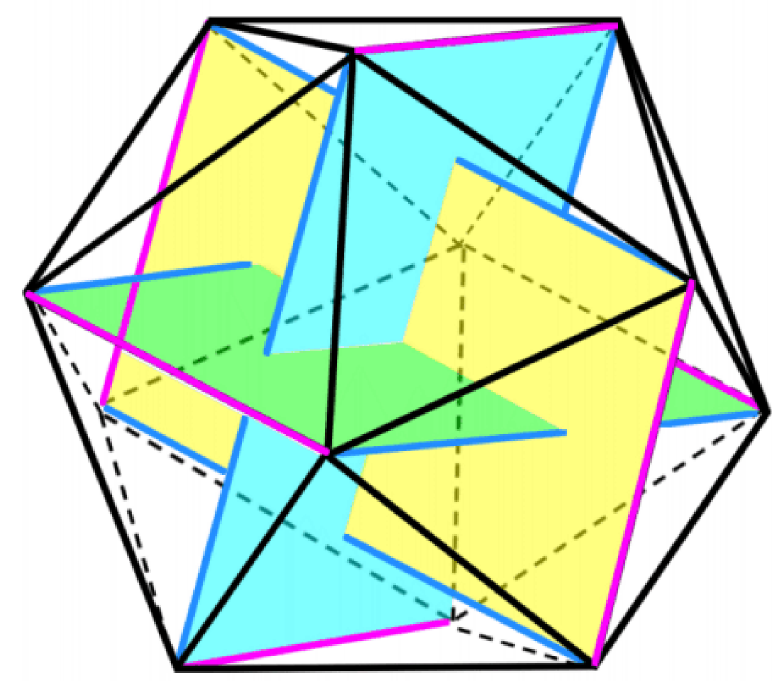
Laban wasn't the first



- Da Vinci considered similar ideas with body motions & rational proportions *Vitruvian Man* (c.1492)
- Golden rectangle & human form (c.f., Pacioli, *De Divina Proportione,* 1509)
- recall: 3 orthogonal golden rectangles produce an icosahedron

Icosahedron & Golden Rectangles

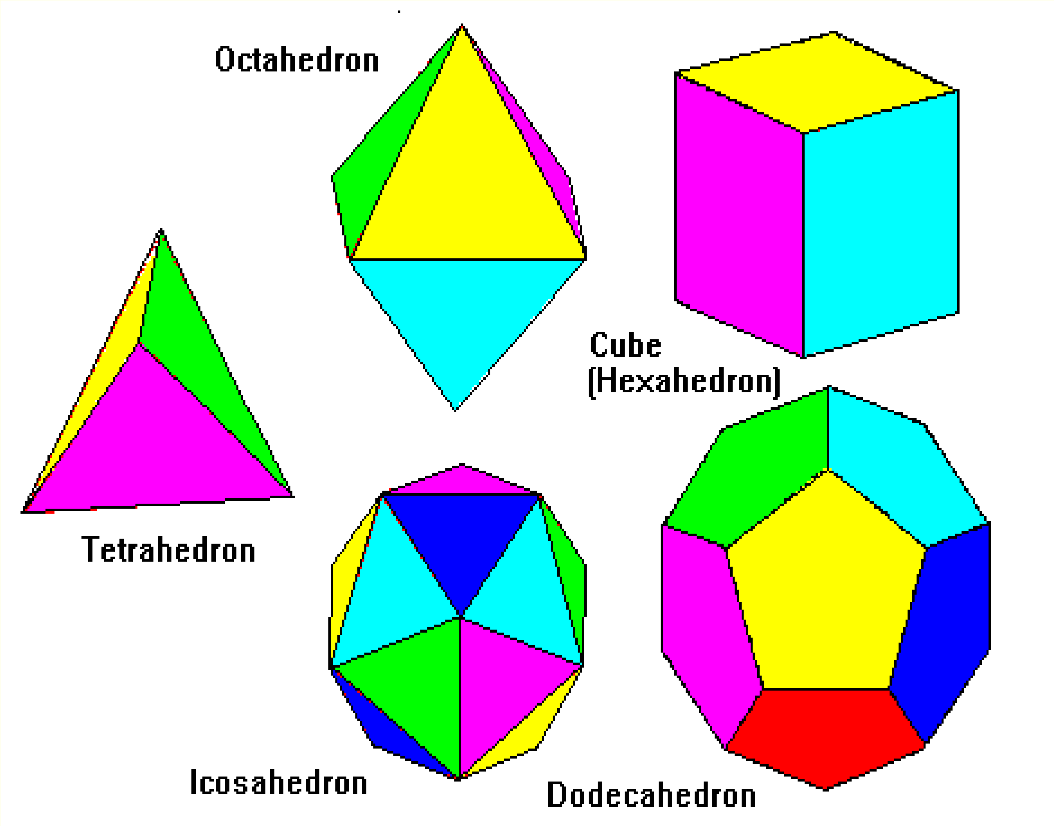
- 3 orthogonal golden rectangles produce an icosahedron
- All 12 vertices are given by the vertices of the 3 rectangles



3 Mutually-Perpendicular Golden Rectangles
Within the Regular Icosahedron

- http://www.hypatia-lovers.com/geometry/Divine_Proportions_of_Icosahedron.gif

The 5 Platonic Solids



Tetrahedron

Cube

Octahedron

Dodecahedron

Icosahedron

+ Duality

4. Cross-disciplinary Teaching

Brought together
liberal arts math class &
intro. to modern dance class (fall)
dance composition class (spring)

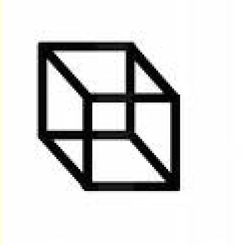
Step 1: dance class visits the math class & we build Platonic solids

4. Cross-disciplinary Teaching

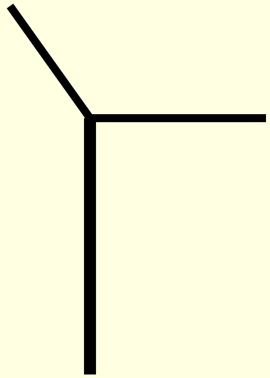
Step 2: math class visits the dance studio & we build Platonic solids

In order, they form
cube
octahedron
dodecahedron
dual octahedron within cube
icosahedron

Cube

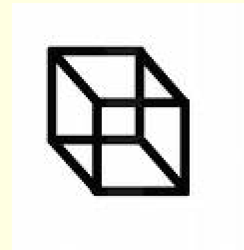


- **36** students, split into 5 groups
  4 groups of **7 students**
  1 group of **8 students**
- All 5 groups formed cube differently
- Group of **8 students** did it in obvious way: each student formed a
  trivalent vertex,
  4 standing, 4 on floor



- Bodies used as edges, etc.

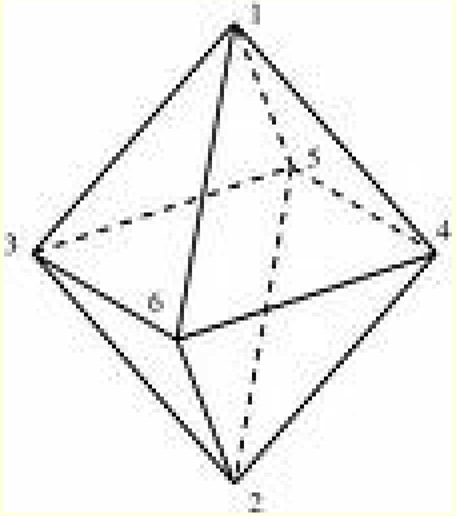
Cube, II



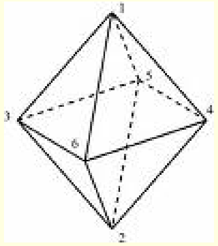
- groups of **7 students** faced tougher task -- forcing more creative, physical motion
- for all groups, floor was natural choice of bottom face
- each group showed their static configuration
- then we asked them to rotate their cube, to make it stand on a vertex
- recurrent concern: how do you represent a regular shape with non-regular bodies?

Octahedron

- 4 groups of **9-11 students**
- more challenging than cube
- some groups used bodies as faces, some as edges

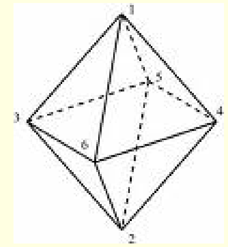


Octahedron, group 1



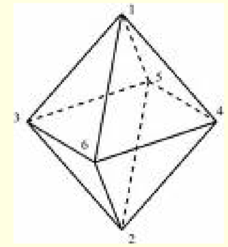
- center axis student
- 4 seated students lean against 4 standing students
- using fellow students to support some body weight

Octahedron, group 2



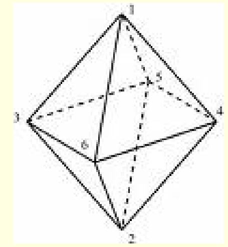
- 1 central figure, who clapped to begin their presentation
- 4 inner students clearly demonstrated the square
- outer students went clockwise; inner ones ccw

Octahedron, group 3



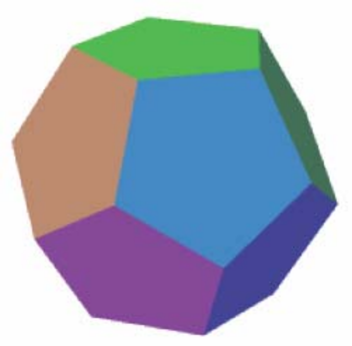
- 4 central figures
- 4 outer students, bent at the waist. They form 2 faces each
- Hands interlock for support

Octahedron, group 4



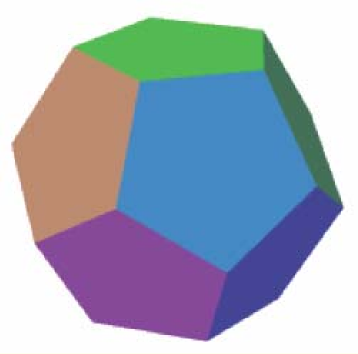
Dodecahedron, group 1

- 5 central students, standing form top pentagon
- 5 outer students, leaning in
- 5 seated students, legs form bottom pentagon



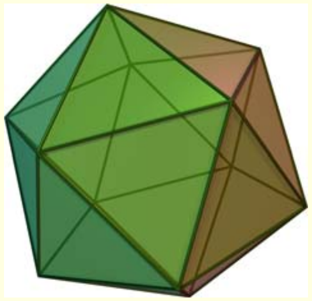
Dodecahedron, group 2

- 3 central students, standing form top pentagon
- 5 outer students, leaning in, arms bent
- 5 seated students
- arms can be 1 or 2 (or 1.5) edges



Dual Octahedron in Cube

Icosahedron was a Struggle



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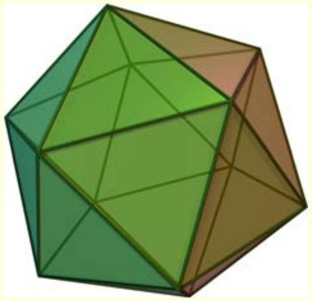
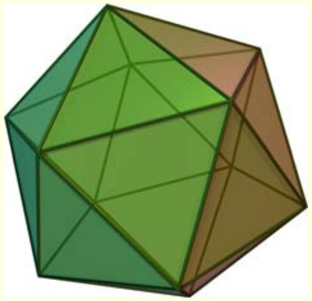


Icosahedron was a Struggle



5. Evaluating Impacts

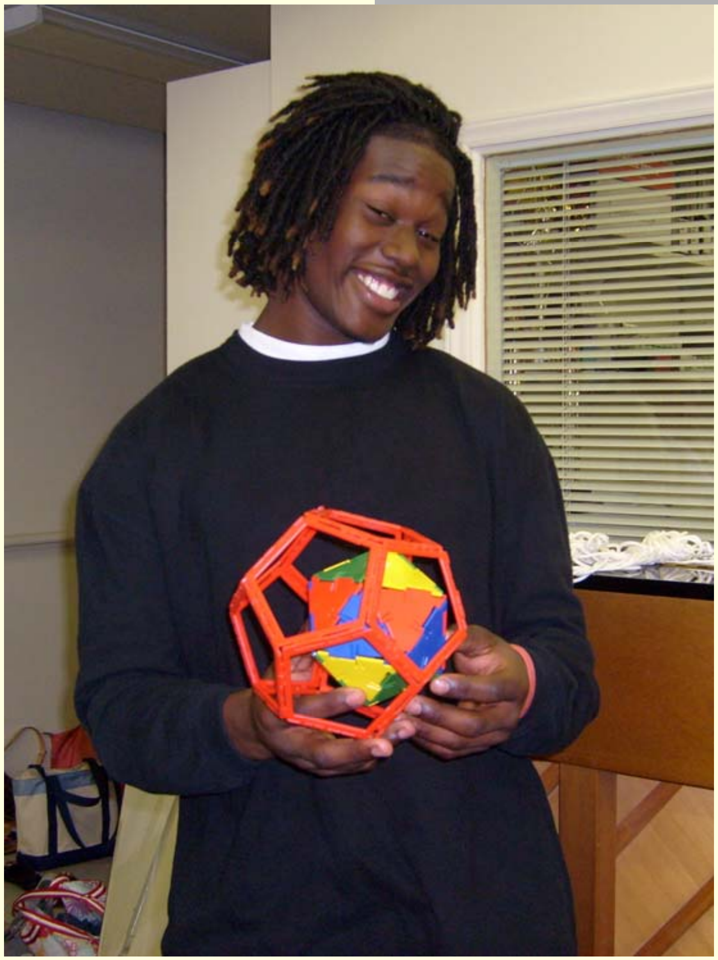
- **Spatial reasoning.** 21 of 22 survey takers: their visualization abilities had increased
- "*The 3-d image we created with bodies is now something that will come to mind anytime I think of a Platonic solid. Attempting to move through space in these shapes was an interesting inspiration for possible spatial patterns to be used in dance choreography.*"
- "*I really got a feel for how 3D these figures are. Dealing with bodies and gravity while trying to construct these figures really showed all of their dimensions and how they can be rotated in space.*"

Evaluating Impacts II

Body sizes & regularity

"I learned how important it is for the angles and sides of the regular polygon to be the same. Our shapes were distorted because not all our bodies were the same."

-anonymous response



(right:) Cyhl Quarles, WFU football

Evaluating Impacts III

- **Weight & balance**

-many students were shocked by the necessity/utility to lean on & support each other

“My favorite part was seeing how to use other bodies and gravity to make different shapes, to support, and to stretch.”

Evaluating Impacts IV

Duality. dancers especially enjoyed the idea of an infinite pattern of solids within solids, getting smaller [or larger]

- *"I could visualize the cube, the octahedron and the duality of the octahedron in the cube better after I experienced them in space."*
- *"Easier to remember what different shapes are after this class. Duality is much more understandable once I was physically able to see it."*

Evaluating Impacts V

Fun. The students loved it!

- *“I thought this was a really fun activity, especially the more complicated solids.”*
- *“Do it again! It’s fun to apply math in different ways.”*
- *“I loved this activity!”*
- *“I loved how beautiful our creation was, and the importance of each individual to make it happen."*
- *“I had a great time doing this and loved getting to think about math in a different way.”*

Broader Impacts: students

- 1 dancer from spring decided, because of this activity, to take Math 107 in the fall … *even though she had already met the requirement*
- more students with dance background enrolled in fall class
- several dancers are planning to incorporate geometric ideas into their spring concert choreography
- overcome math phobia; math 107 is ‘fun’

Broader Impacts: faculty

- influence of geometry on Soriano's recent & future works
- as of yet, no research connections for me
- affects my ideas on how students can best learn spatial reasoning & symmetry
- we're presenting at (1) math conferences
  (2) dance panels
  (3) on-campus teaching/learning fair
- paper forthcoming

Thanks for coming!!!