Northwestern | ENGINEERING

Streamlined Implementation of Interactive 3D Graphics in Course Materials

TEACHx — 2019

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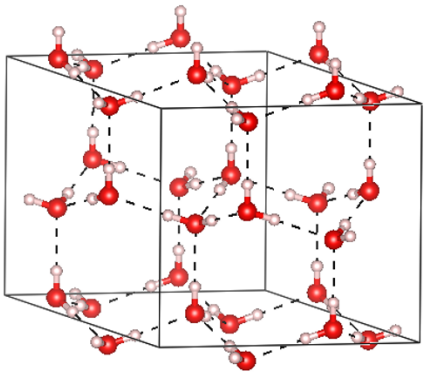
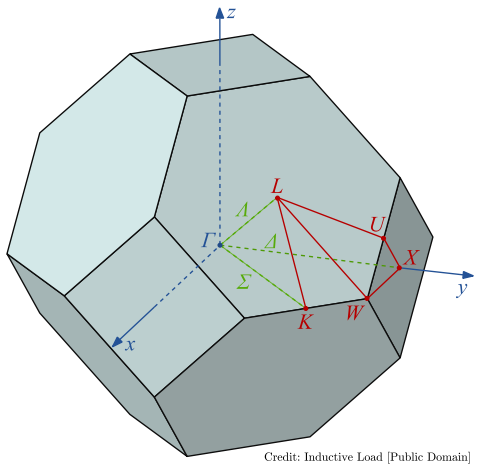
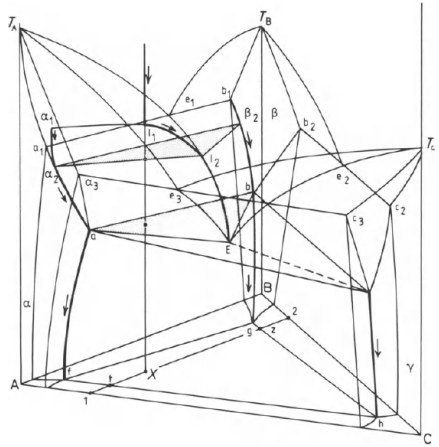
1. **The Domain-specific Problem:** *Engineering students from all background struggle with visualization/mental manipulation of 3D objects. Materials Science is inherently 3D: crystal structures, ternary phase diagrams, electronic structure, multi-variable optimization, etc.*
2. **The Student-centered Problem:** Students do not have time (or motivation) to learn new computer software for each visualization exercise.

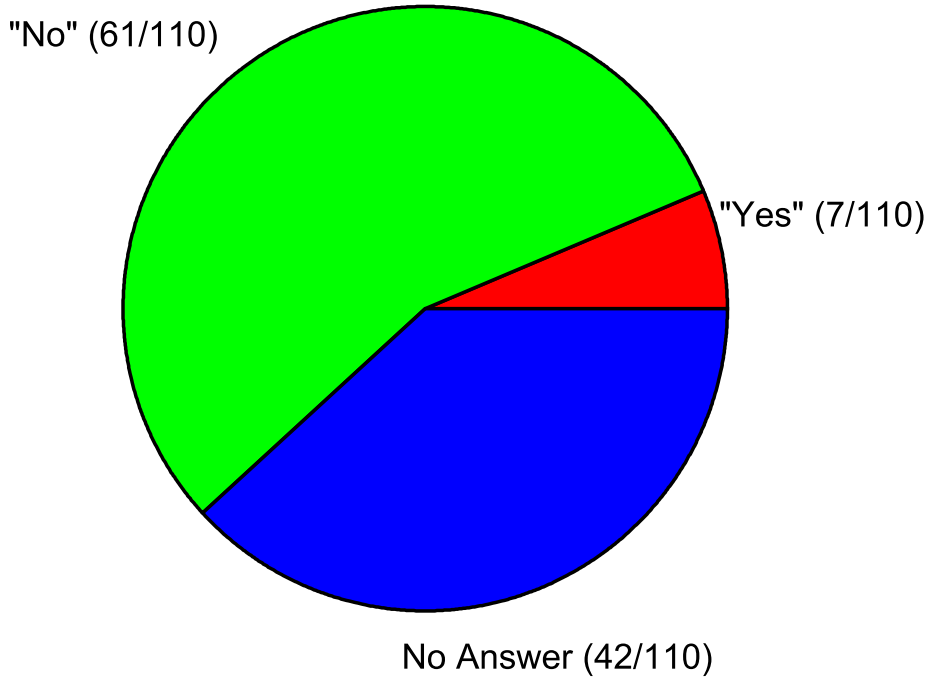




Credit: Inductive Load [Public Domain]



Did you use VESTA software to help with 3D visualization?



Why did/didn't you use VESTA?

- "Very useful!"
- "Helped me learn"
- "Not explicitly required..."
- "Another new software?"
- "No time"
- "Make it mandatory"
- "What is VESTA??"

Does access to 3D models help with student learning?*

	Enhancement in Learning	
Modality	Low-level Spacial Ability	High-level Spatial Ability
Dimensionality	High	Medium
Realism	Medium	Medium
Dynamics	High	Medium
Interactivity	Medium	Medium
Multi-modality	Low	Low

Conclusions: Yes, this should help! Concentrate on:

1. **Content**
   - Dimensionality
   - Realism
   - Dynamics
   - Interactivity
2. **Student experience**
   - Reducing barriers.
   - Streamline modalities.
   - Make it fun.
   - Impress them!

*T.N Höffer, *Spatial Ability: Its Influence on Learning with Visualizations — a Meta-Analytic Review*, Educ. Psychol. Rev., (2010) 22:245-269

Big questions:

- How do we utilize 3D graphics in an *unavoidable* but *unobtrusive* way?
- How do we make student *want* to use these resources?
- Can we scaffold this project so that other instructors can use it with relative ease?

Considerations:

Necessities:

- **Free/cheap**
- Flexible/powerful
- **User-friendly**
- Web/**PDF**/Powerpoint-compatible.

Idealities:

- Creator-friendly
- Student feedback system
- Active community
- Learning analytics

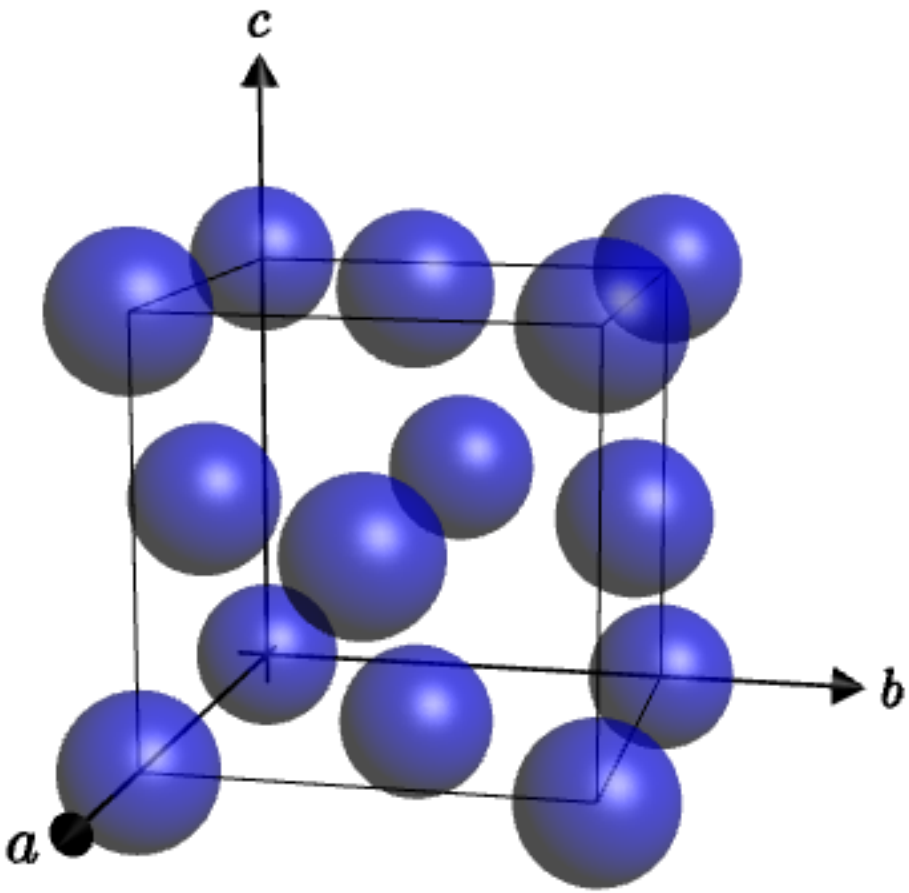
Asymptote — Vector Graphics Software †

- PDF formatting is nearly ubiquitous as a medium for documentation.‡
- LaTeX-compatible
- Asymptote-produced PRC files:
  - High-level graphics commands
  - TeX-formatted labeling
  - ISO-standardized
  - Viewable with Adobe Reader
  - Javascript-enabled views, animations, interactivity.

†Developer: John Bowman, U. of Alberta

‡Well...

Crystal Structure



Hard Sphere 1

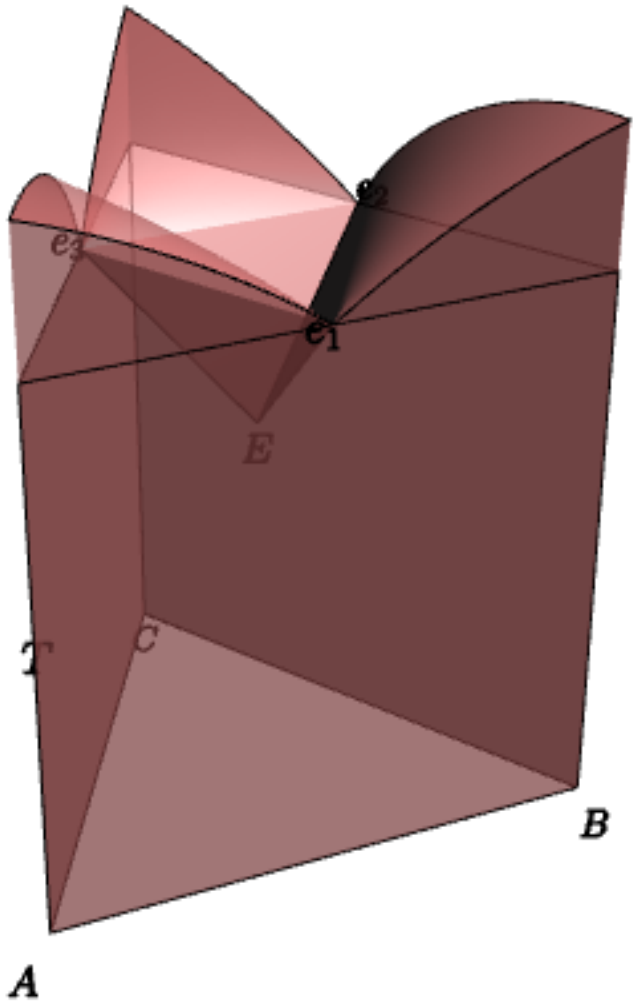
Hard Sphere 2

Octahedral Sites

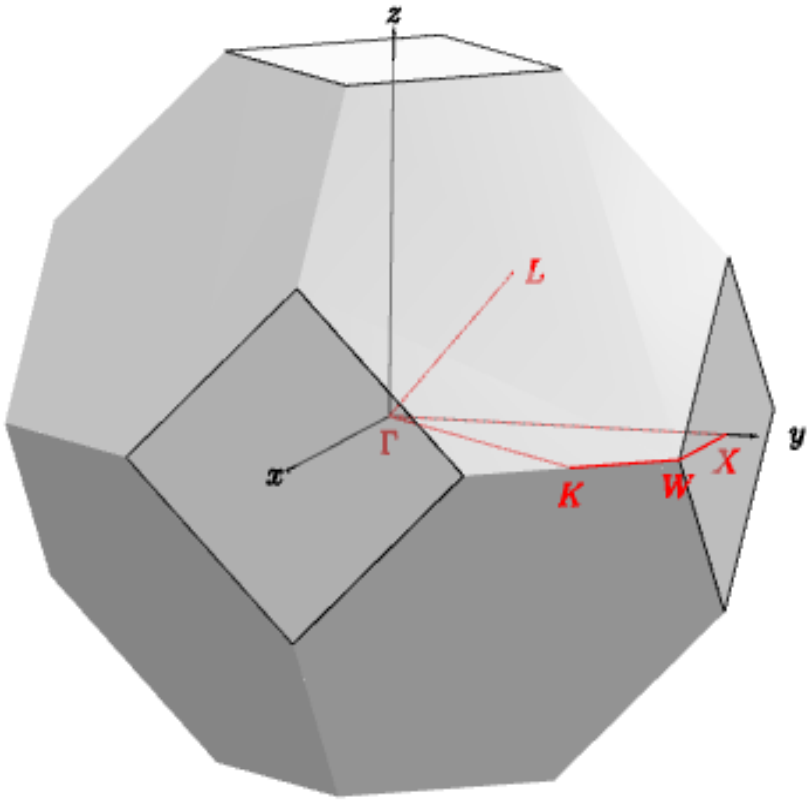
All Objects

Ternary Phase Diagram

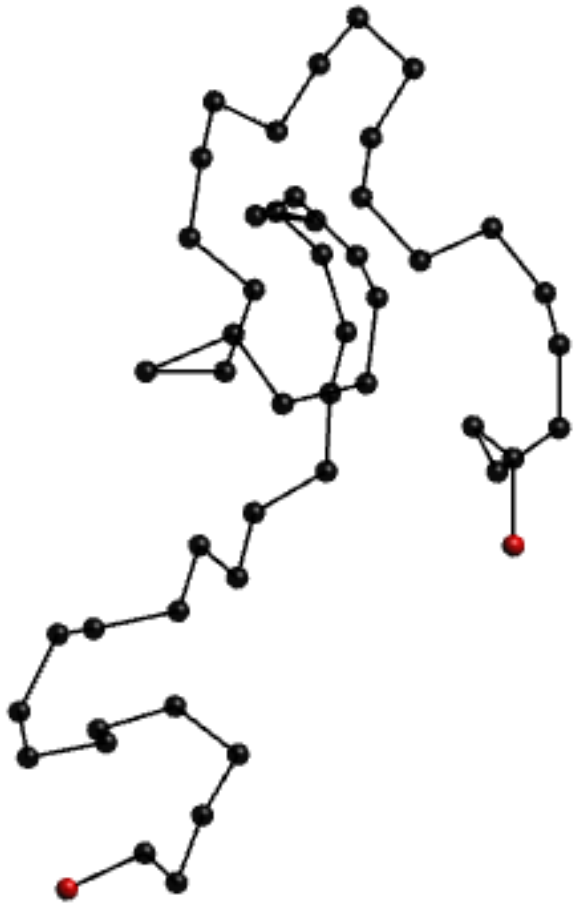
View 2



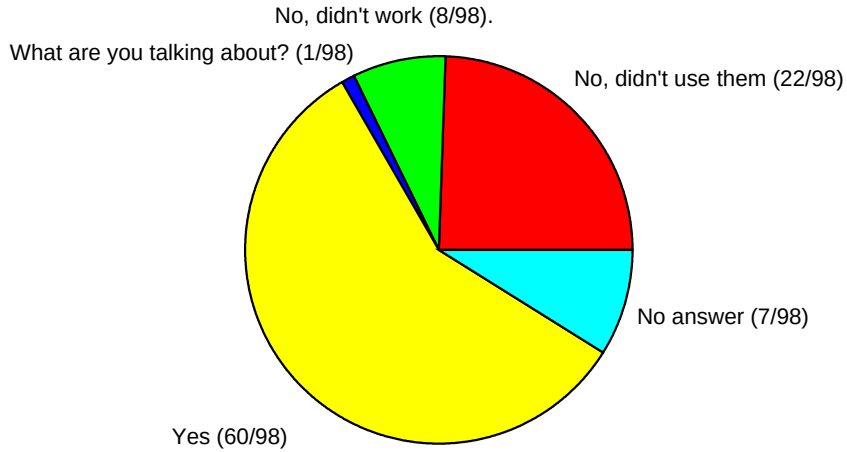
Brillouin Zone



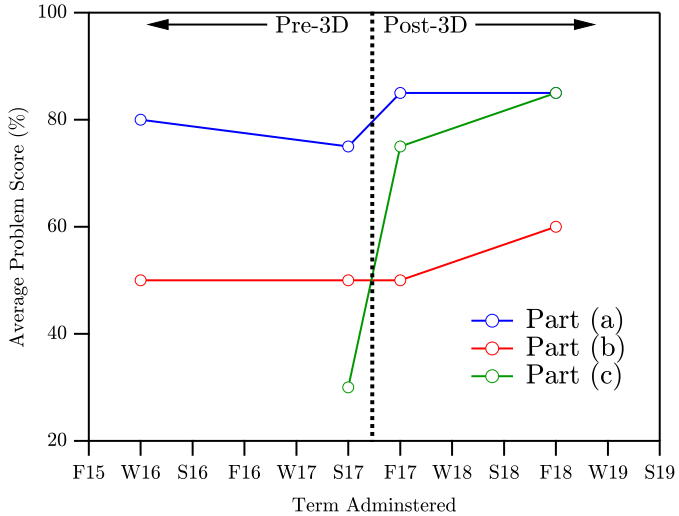
Polymer Structure



Did you (students) find that the 3D graphics helped you learn?



Is there evidence of improvement on assessments?



How could the embedded, rotatable 3D graphics be improved to help with visualization of crystal structures?

- "They were very good as-in" (42).
- "They are unnecessary" (6)
- **"They were a bit buggy"** (6)
- **"Improve accessibility"** (4)
- "More preset views/details" (3)
- "Make them into videos" (2)
- "They were confusing" (2)
- "Make them into model kits" (1)

Successes

- Students like them, in general.
- Students say they learn from them.
- They work (most of the time).
- They're very pretty.
- Transferable — paste from one PDF to the next!

Challenges

- 10% of students cannot follow the directions to get them to work.
- Adobe is no longer the default PDF viewer.
- Creation is complex...
- User-end settings and hardware:
  - No tablets
  - No phones
  - Loading time
  - Security
  - Adobe is fickle...
- Does not work with PowerPoint (although nothing does, yet).
- No clear improvement in outcomes.

TO THE WEB!

Collaborations with Alem Snyder (Python,) and Aaron Geller (WebGL).

- Our students *live on the Web*
- Compatible with *Canvas*
- Platform-independent (small devices)
- Not beholden to Adobe
- Larger community, more active developments.
- Learning analytics (Google Analytics)

Would you like to produce 3D graphics for your course (Web or PDF)? Join our community!

- Physics/Astrophysics
- Mathematics
- Mechanical Engineering
- Geology/Geophysics
- General data visualization/interaction
- Art/Imaging
- Medicine/Imaging
- etc...

If so, contact us:

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