



College Students' Mental Models of Atomic Friction and Lubrication

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Research Questions

- What are the existing models of introductory college physics students regarding friction and related phenomena?
- How do students build and use models in explaining common everyday phenomena related to friction?

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Methodology

- **Semi-Structured Clinical Interview**¹
 - ⇒ 2 sessions (one hour each)
 - ⇒ Videotaped
- **Interview Protocol**
 - ⇒ Pilot-tested with 1 grad and 2 undergrads.
 - ⇒ Main Issues:
 - Surface at Different Length Scales
 - Cause of friction at the atomic level
 - Lubricating Mechanism of Oil

Focus of this Talk

¹Piaget (1929)

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Methodology

- **Phenomenographic Analysis**^{2,3}
 - Categories emerged from students' responses.
(Inter-rater reliability of categories is at least 80%)
- **Thematic Analysis**⁴
 - Themes emerged from categories in different contexts.

²Marton (1986) ³Svensson & Theman(1983)
⁴Bogdan & Bilken (1998)

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The Participants of the Study

Major	No. of Students
Mech. Engineering	4
Secondary Education	3
Computer Science	1
Marketing	1
Microbiology	1
Undecided	1
Total	11

⇒ enrolled in Conceptual Modern Physics (Spring 2004).
⇒ had at least one semester of college physics.

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RESULTS

Surfaces at Different Length Scales

- If we keep zooming in we'll eventually get into the atomic level where we'll see individual atoms. (11 students)
- Surfaces have peaks and valleys even at the atomic level (7 students).



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Models Used to Explain (Static) Friction

Intertwining/Interlocking (5 students)

"...when I try to move it I got to pull them out so there will be some friction because there will be some particles getting intertwined like that (fingers of hand intertwining)"



Bonding Model (3 students**)

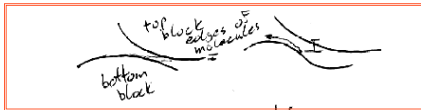
"well I would say friction is the bond between the atoms I don't know if that's electronic, or ionic bonding"

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Models Used to Explain (Static) Friction

Rubbing/Hitting/Sliding (5 students**)

"they are touching but they don't interact any more than just the physical contact.....one of them is moving and one of them isn't moving so they rub together"



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Models For Why Static > Kinetic Friction

Getting Smoother (1 student)

"The way this works basically is it is more rough when it wasn't moving than when it was."

Fewer Bonds (2 student)

"When it has started moving, let's say they might not have enough time to form that (bond) one and that (bond) one. So there's less number of bonds to be broken."

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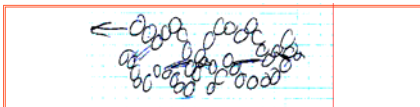
Models For Why Static > Kinetic Friction

Changing Downward Force (1 student)

"when it is at rest there's more pressure between the atoms....when it starts moving you have less force pulling down"

Skimming Over the Top (5 students)

"When you're moving it they're gonna be not as intertwined...it's gonna be like coming across and doing that (hand moving past the other)"

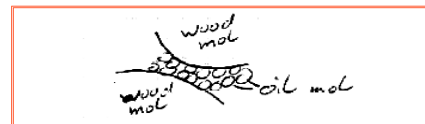


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With Lubrication (Oil)

Ball Bearing (5 students)

"I think it might be possible that they move past one another easier but it could be that maybe oil molecules roll"



Fewer/Weaker Bonds (1 student)

"They don't exhibit as much intermolecular bonds between each oil molecule than between oil and wood molecules so they can move past one another easier than the wood on wood."

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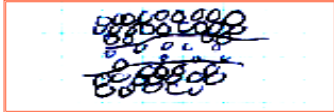
With Lubrication (Oil)

Reduction of Bumps and Valleys (2 student*)

"Oil is not solid.. if you draw it **forms like a uniform line** between the two...in a sense makes it lot more flat to where nothing can stick out and go against a stuff as it went by."

Floating Model (5 students*)

"oil will help **separate** these **bumps and valleys** such that they don't have to interact with the full scale"



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Walking on Dry Ground

⇒ Students used the block of wood on the table surface model

Walking on Wet Ground

⇒ Students used oil on wood model

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EMERGENT THEME

Macroscopic Ideas in Microscopic World

□ Friction is due to mechanical interactions

- ⇒ meshing up of bumps and valleys
- ⇒ rubbing of atoms
- ⇒ downward force that presses surfaces together

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TRANSFER IS UBIQUITOUS

Students transfer..

- daily experiences
- knowledge from previous science courses
- previous explanations

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FUTURE DIRECTIONS

- Do teaching interviews
- Develop Curriculum Materials
- Pilot Test Developed Curriculum Materials

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Contact Information

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Thank You!!!

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