Context and reasoning: The resistance to "resistance"

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Do experts reason differently across disciplines?

- Students and instructors acknowledge that Human Anatomy and Physiology (HA&P) is a difficult course.
- Discipline-based factors such as causal reasoning, thinking about dynamic systems, and thinking across dynamic systems may make HA&P particularly challenging.[1]
- Previous literature has explored the role of prior knowledge and intuition on students' incorrect biology conceptions in other biology sub-domains.[2]
- We are exploring how context affects expert reasoning. Specifically, we are interested in:
  - Does **surface context** influence expert reasoning?
  - What experiential knowledge affects how the expert frame these problems (**deep context**)?
  - How do experts across disciplines think about the term "resistance"?
  - What resources are experts drawing on within and across disciplines when reasoning about resistance?

Surface context doesn't matter…

- Rankings amongst departments were relatively similar—no major department trends (*Tab 1*).
- Although resistance was the most disputed sub-question, it was the most agreed upon sub-question by experts in all departments.
- **Overall, *surface context* does not seem to matter as 8 of 10 experts did not change their answers between contexts.**
- **However, we found evidence of a *deep contextual effect* when coding experts' reasonings (*Tab 2*).**

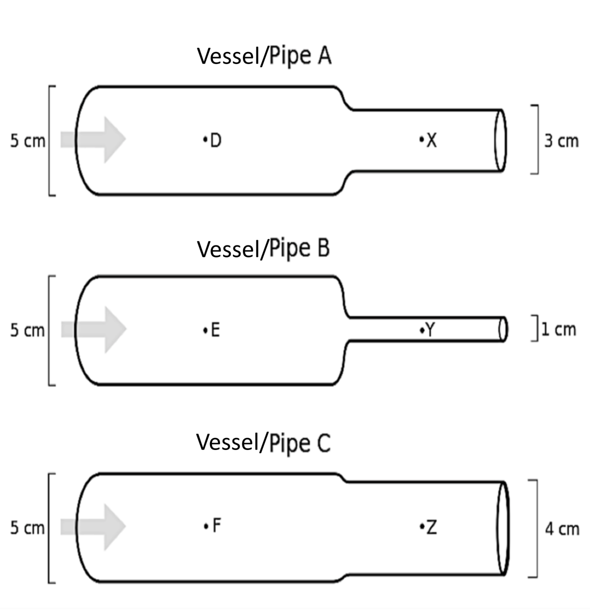
Table 1: Simplified rankings (highest to lowest) for each sub-question on both parts of isomorphic prompt

Rankings

	Out of Context				In Context			
	Speed	Fluid Flow Rate	Pressure	Resistance	Speed	Fluid Flow Rate	Pressure	Resistance
BIOLOGY	Pipe				Blood			
Bio1	CAB	CAB	BAC	BAC	CAB	CAB	BAC	BAC
Bio2	BAC	equal	BAC	BAC	BAC	equal	BAC	BAC
Bio3	BAC	CAB	BAC	BAC	BAC	CAB	equal	BAC
Bio4	BAC	BAC	BAC	BAC	BAC	BAC	BAC	BAC
PHYSICS	Blood				Pipe			
Phys1	BAC	equal	BAC	BAC	BAC	equal	-	BAC
Phys2	BAC	equal	equal	BAC	BAC	equal	equal	BAC
Phys3	BAC	equal	BAC	BAC	BAC	equal	BAC	BAC
ENGINEERING	Blood				Pipe			
Eng1	BAC	equal	BAC	BAC	BAC	equal	BAC	BAC
Eng2	BAC	equal	CAB	BAC	BAC	equal	CAB	BAC
Eng3	equal	CAB	equal	CAB	equal	CAB	equal	BAC

Interviews, prompts, and people – Oh my!

- We used isomorphic prompts to ask experts about fluid flow in water in pipes and blood in vessels (*Fig 1*).
- Isomorphic prompts allow us to present the same concept (e.g. fluid flow through tubes) in different contexts (e.g. biology vs. physics) while controlling for task difficulty.



The figure below shows three different **blood vessels/pipes** (A, B, and C) with **blood/water** flowing through them (designated by the gray arrow on the left). The volume of **blood/water** entering the left end of the **blood vessel/pipe** every second is the same in Systems A, B, and C. The pressure in the **blood/water** is the same at points D, E, and F. The **blood/water** viscosity is very low. The diameter on the left end of each **blood vessel/pipe** is the same (5 cm).

Speed (S) Fluid Flow Rate (F)
Pressure (P) Resistance (R)

Figure 1: Interview protocol for isomorphic prompts

- We conducted semi-structured interviews with 10 NDSU faculty (4 Biology, 3 Engineering, 3 Physics).
- Participants were presented with both forms of the isomorphic prompt. They were first given their non-discipline context, followed by a distractor question, and then their discipline context (Fig 2).

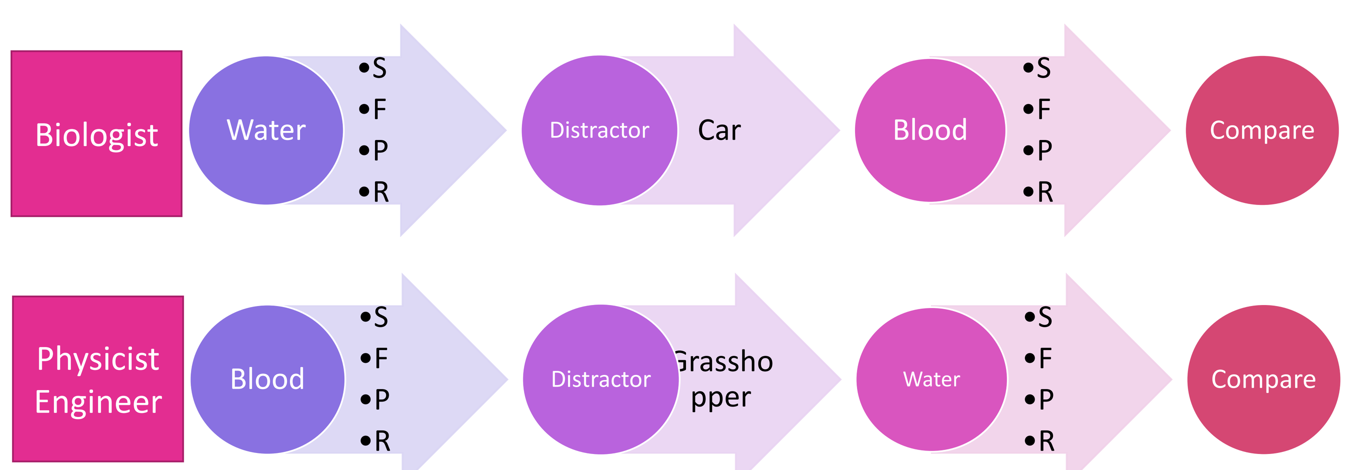


Figure 2: Order of presentation of interview protocol

…but what about **deep** context?

*Table 2: Thematic coding rubric. "Yes" or "No" indicates presence of the theme. * indicates specific representation/code within that theme*

Code	Bio1	Bio2	Bio3	Bio4	Phys1	Phys2	Phys3	Eng1	Eng2	Eng3
Recognize "Resistance"	No	No	No	Yes	No	No	No	Yes	Yes	Yes
Uncertainty	*		*				*			
Alternative Terms	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Viscosity						*	*			
Head/P/FR/E Loss								*	*	
Electricity		*	*		*		*			
Resistivity					*					
Compactivity			*							
Related Terms/Concepts	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geometry (G)	*	*	*	*	*	*	*	*		*
Speed (SP)					*			*		*
Flow Rate (FR)				*					*	
Pressure (P)	*			*	*			*	*	
Volume (VO)			*	*						
Friction (FR)			*				*	*		
Energy (E)								*	*	
Force (FO)				*	*					*
Shear/Loss (SL)						*				
Viscosity (VI)						*				
Density (D)						*			*	
Context Effects	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Context Switch	*							*		
Context Does Matter			*				*	*		
Context Doesn't Matter					*	*	*			
Analogies			*	*	*		*	*		
Intrinsic vs. Extrinsic Properties	No	Yes	Yes	No	Yes	Yes	No	No	No	Yes
Intrinsic			*		*	*				
Extrinsic		*	*		*	*				*
Accept biology definition	Yes	Yes	Yes	Yes	No	No	Yes	No	N/A	Yes
Fully accepts	*	*	*	*						*
Hesitant to accept					*	*	*	*		
Modifies				*	*	*		*		

While the context of the problem itself did not influence expert reasoning, the education, intuitions, and experiences of the experts themselves were significant.

Biologists and physicists struggled to recognize resistance while engineers did not.

Almost half of our sample population associated resistance with electricity. Physicists tended to mention viscosity as an equivalent term to resistance.

- BIO3; "I mean there's definitely resistance to flow in my prior experiences, but I couldn't think of any real world examples other than electricity."
- PHYS2; "I guess that would go closer to it being a viscosity, which would be an intrinsic fluid property, and then they would all be the same."

Experts among all 3 departments mentioned the effect of geometry of the system on the resistance (*Fig 3*).

- BIO2; "…but it's trying to flow in but it's limited by this bottleneck here {pointing to handout}, and so that's opposing the movement a bit."
- PHYS; "So as you put it through a smaller diameter, you increase the velocity, you get more resistance, you start to eat up that pressure as it flows through the pipe."

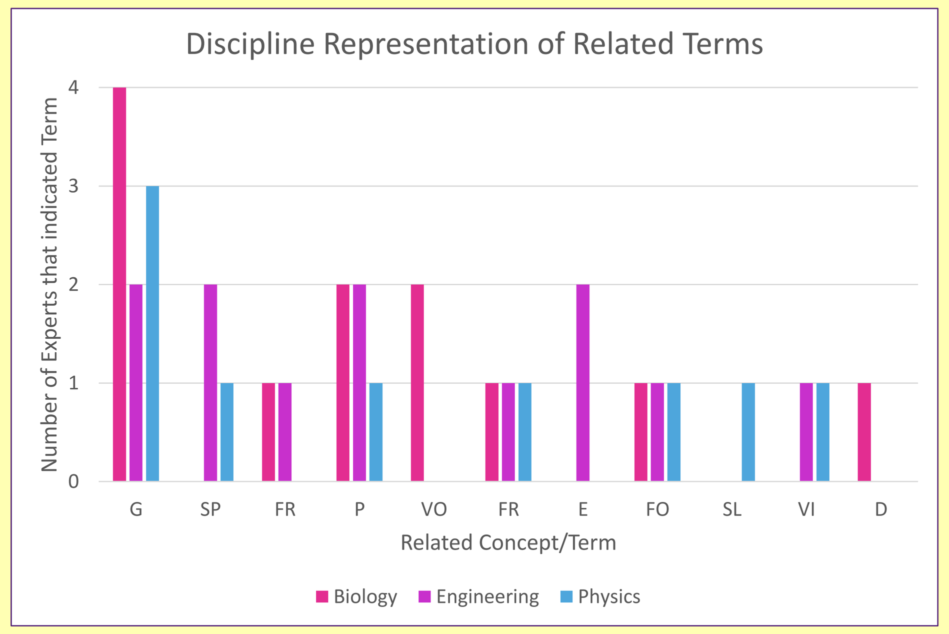


Figure 3: Number of individuals that mentioned each related term/concept, categorized by discipline

All physicists in our sample directly stated or implied that context would not affect system function.

- PHYS1; "So yeah, it's all analogous to what we already did for the blood."
- PHYS3; "But, but I don't think the answers would be different."

Results indicated no consistent trends with regard to the intrinsic or extrinsic nature of resistance, although multiple experts mentioned both in their interviews.

Biologists tended to accept the biological definition of resistance that we offered them while other departments were hesitant to do so. Going further, we would like to conduct textbook analysis of biology, physics, and engineering textbooks to gain a better understanding of how resistance is represented in different science disciplines.

References

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Acknowledgments

The authors would like to thank the National Science Foundation for supporting this research via NSF grant number, DUE 1560142. I would also like to thank the NDSU Growing up STEM REU program and all of its mentors for sponsoring my participation and putting up with my shenanigans. Additional thanks to Warren Christensen and John Buncher for their assistance on the project. And a special thank you to Dr. Nicholas Pullen, Dr. Robin Hirsch-Jacobson, Dr. Kimberly Keller, and Dr. Timothy Hanrahan for helping me to discover, apply to, and eventually be accepted into this program. You da real MVPs!

Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.