

Scaffolding Students' Understanding Of Force In Pulley Systems

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This work is funded in part by U.S. Department of Education, Institute of Education Sciences, Award # R305A080507

OBJECTIVE

Investigate how students interacting with physical and virtual pulleys discuss force while comparing various pulley systems.

WHY PULLEYS? Pulleys are not part of the regular course curriculum, so we can provide students with an authentic learning experience.

BACKGROUND

Previous studies¹⁻⁴ comparing the effectiveness of physical and virtual manipulatives have shown:

Virtual Experiments ≥ Physical Experiments

Our previous research⁵ has shown that students learn the concept of force equally well using physical and virtual manipulatives.

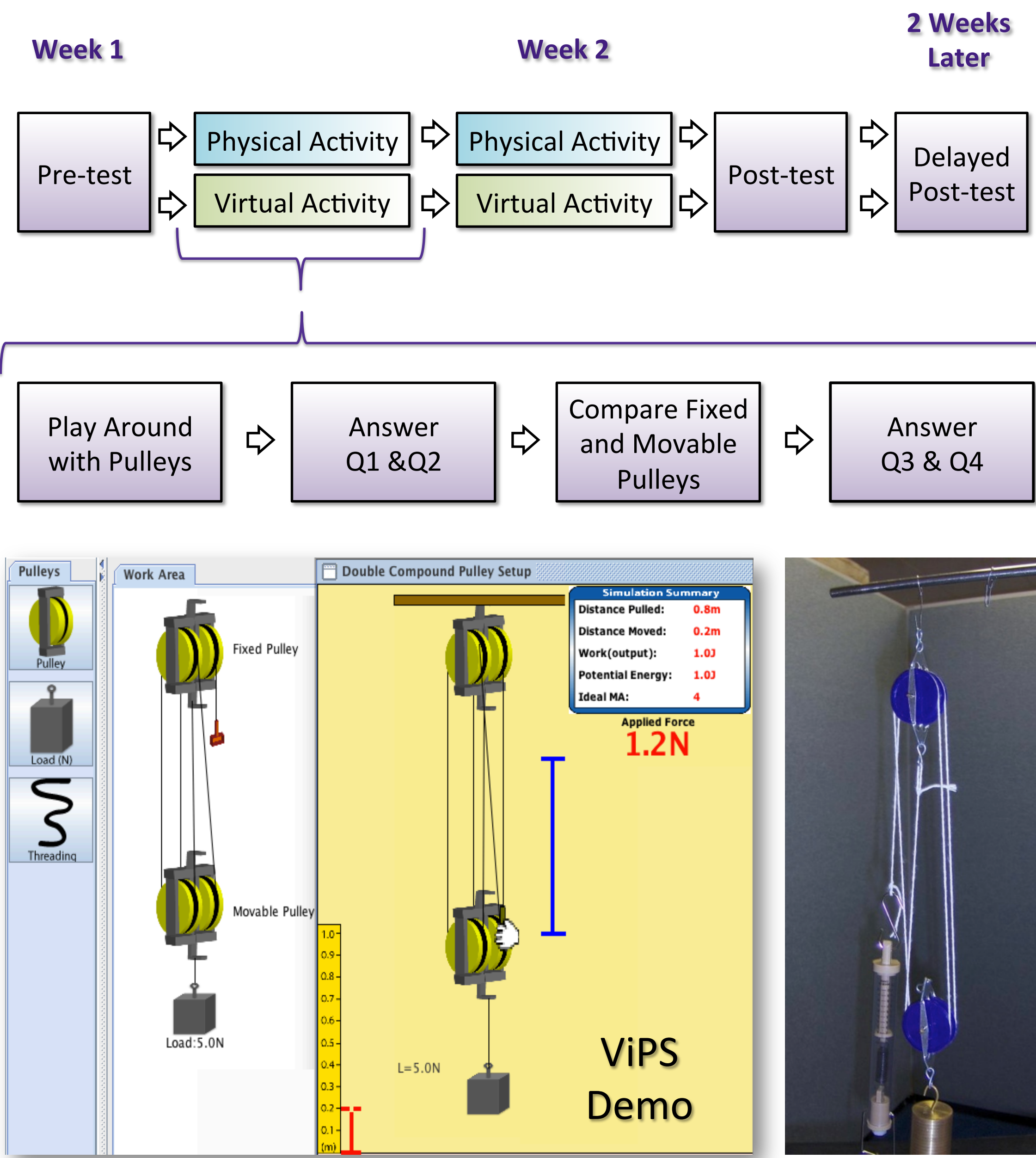
METHODS

Participants: non-science majors enrolled in conceptual-based physics laboratory

Materials: ViPS Demo Simulation & physical pulleys (see below), tests, and worksheets designed to scaffold student understanding

Procedure: Students completed similar activities with pulleys using physical (N=74) OR virtual (N=69) manipulatives and answered analysis questions

Analysis: Worksheet responses were coded and analyzed with chi-square test



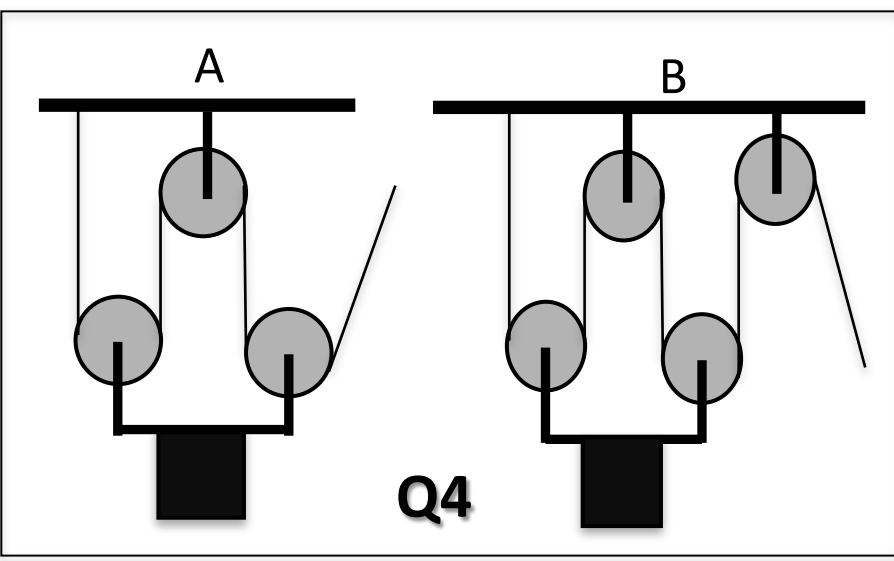
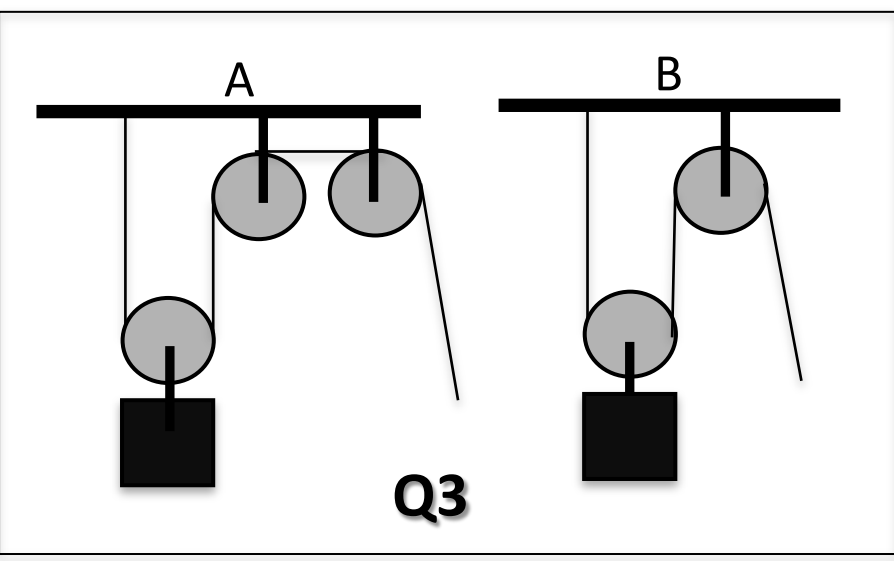
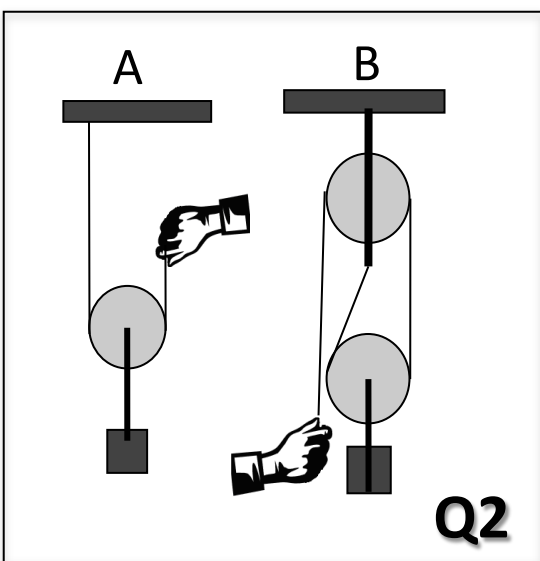
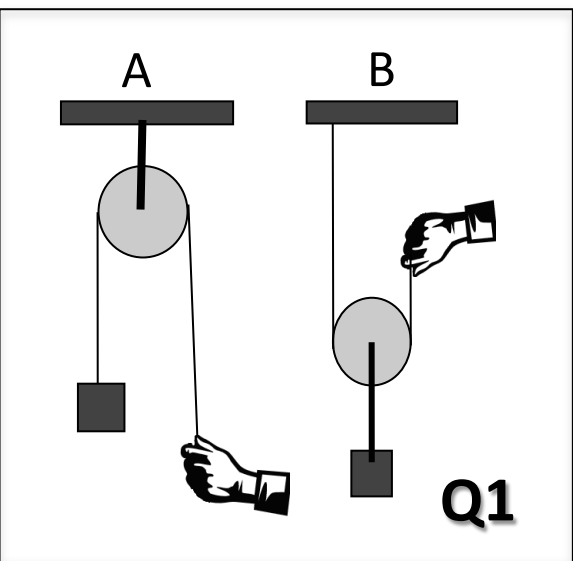
REFERENCES

1. D. Klahr, L.M. Triona, and C. Williams, *Journal of Research in Science Teaching* **44**, 183–203 (2007).
2. N.D. Finkelstein, W.K. Adams, C.J. Keller, P.B. Kohl, K.K. Perkins, N.S. Podolefsky, S. Reid, and R. LeMaster, *Phys. Rev. ST Phys. Educ. Res.* **1**, 010103 (2005).
3. Z.C. Zacharia and C.P. Constantinou, *American Journal of Physics* **76**, 425–430 (2008).
4. Z.C. Zacharia, G. Olympiou, M. Papaevripidou, *Journal of Research in Science Teaching* **45** (9), 1021–1035 (2008).
5. J.J. Chini, A.M. Madsen, E. Gire, N.S. Rebello, and S. Puntambekar, *Phys. Rev. ST Phys. Educ. Res.* **8**, 010113 (2012).

QUESTIONS

Which pulley system requires the least amount of applied force to lift the load (the weight)? (The weights are equal in both systems.)

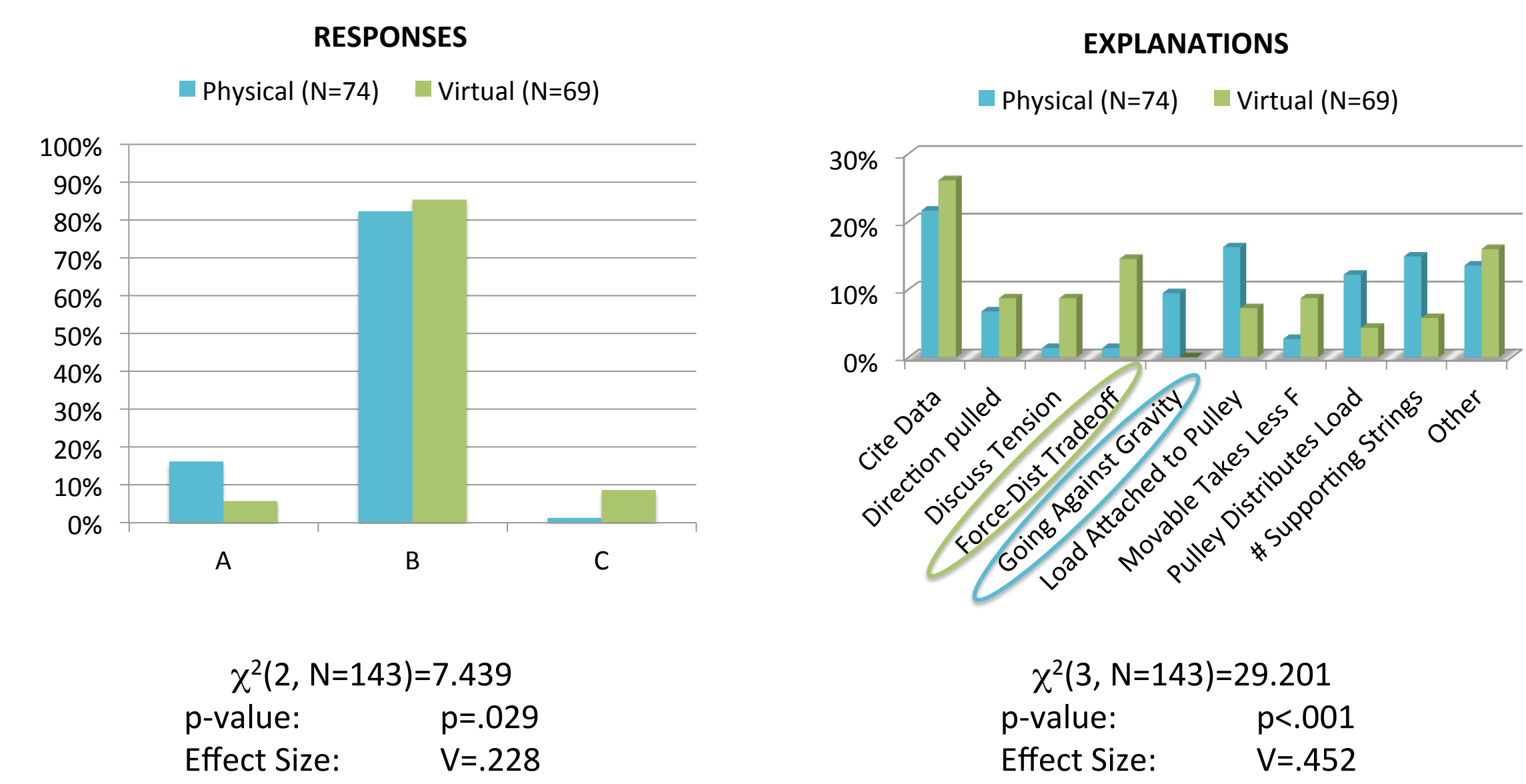
- A) Pulley system A
B) Pulley system B
C) They require the same applied force



QUESTION 1

Physical group more likely to talk about gravity

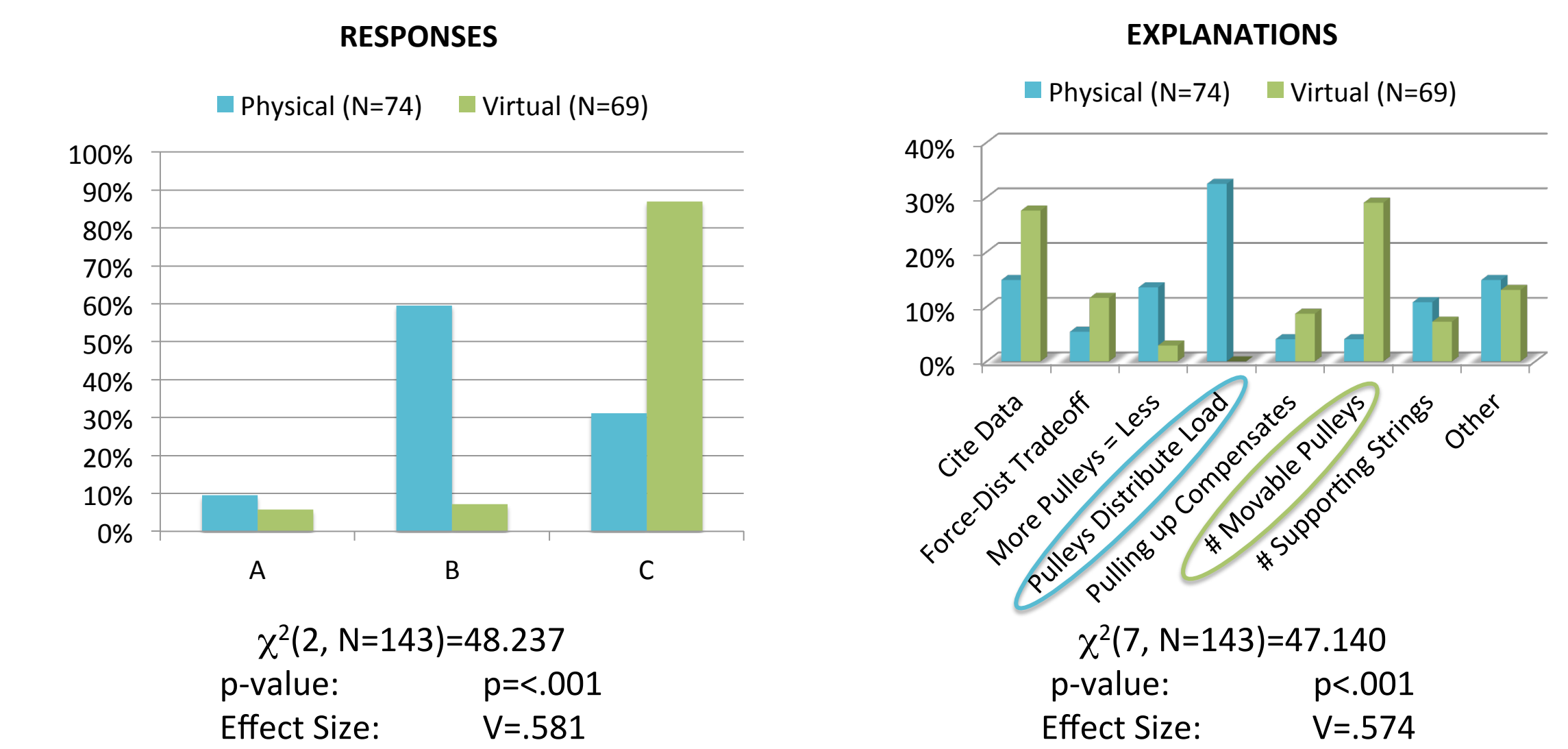
Virtual group more likely to talk about force-distance tradeoff



QUESTION 2

Physical more likely to talk about the pulleys distributing the weight

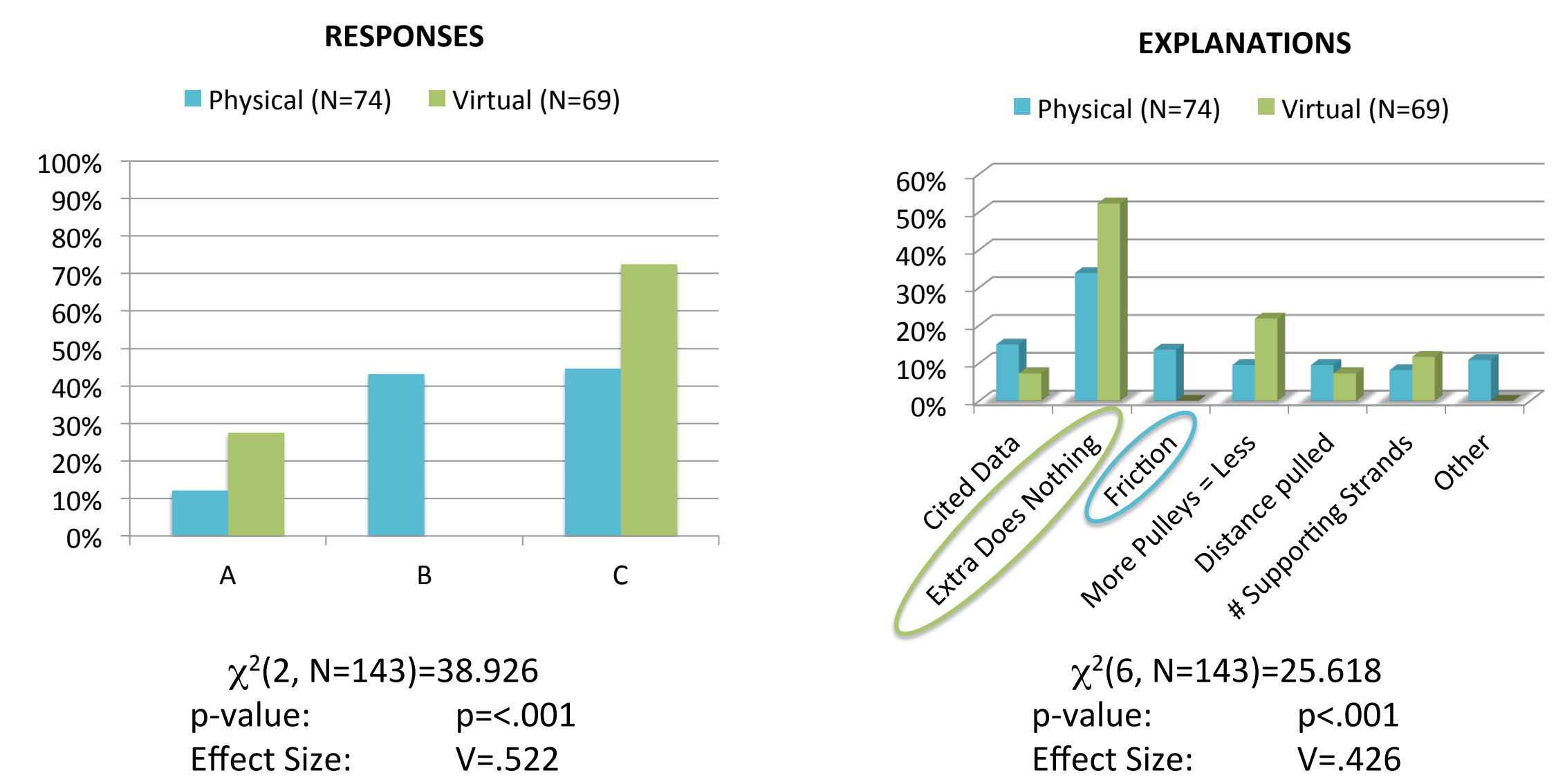
Virtual more likely to observe that the systems have the same number of movable pulleys



QUESTION 3

Physical group more likely to discuss friction

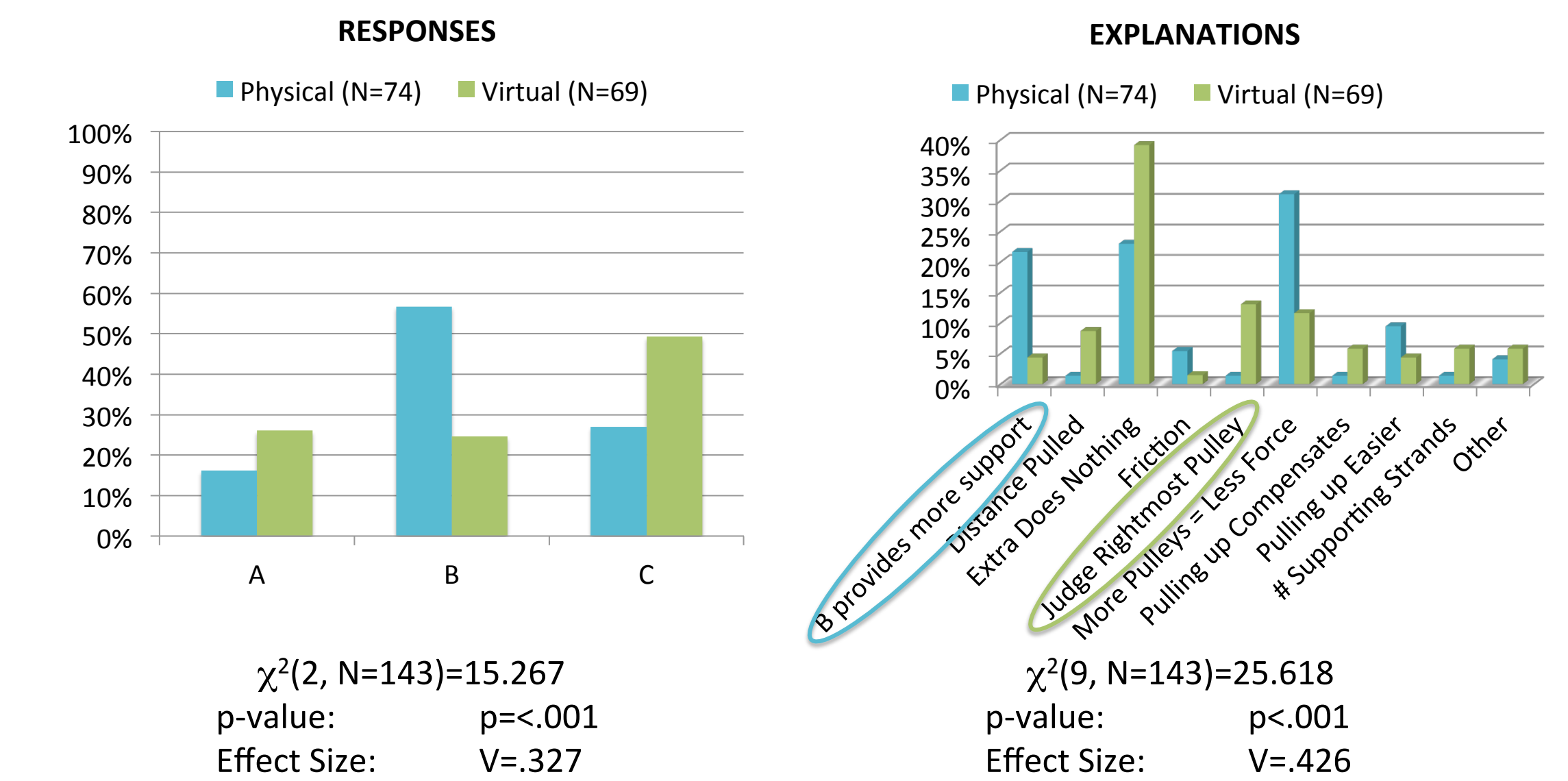
Virtual group more likely to state that extra fixed pulley does nothing



QUESTION 4

Physical group more likely to state that there are more pulleys to support the load

Virtual group more likely to judge only the rightmost pulley



CONCLUSIONS & IMPLICATIONS

Overall, the physical group is more likely to discuss real-world effects like gravity and friction and talk about the pulleys distributing the weight

➤ Could be due to physically stringing the pulleys

Virtual group more likely to break systems into units of single fixed and single movable pulleys

➤ Could be due to seeing pulleys individually on the screen

Students activate different resources when working with pulleys

Instructors should keep in mind instructional goals when choosing between physical and virtual experiments.