Optimal Model-Order for a Moon Phases Lab with Virtual and Physical Components

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Objective:

We designed a middle school lab experience to help students understand the cause of the Moon's phases, using a combination of physical models (styrofoam balls and lamps) and computer models (WorldWide Telescope, WWT). We tested how model order (Foam then WWT, vs. WWT then Foam) would impact student learning.

Figure 1: Eighth grade students using the Moon Phases Visualization Lab in an urban middle school in MA. *Left*: Students work with the physical model that includes a lamp to represent the Sun and a styrofoam ball to represent the Moon. *Center*: Students work with a virtual model on a laptop. *Right*: A screenshot from the virtual model in WorldWide Telescope, showing both a view of what the Moon looks like as seen from Earth (main view); and how the Sun, Earth, and Moon are configured in an overhead "space-based" view (inset).

Theoretical framework:

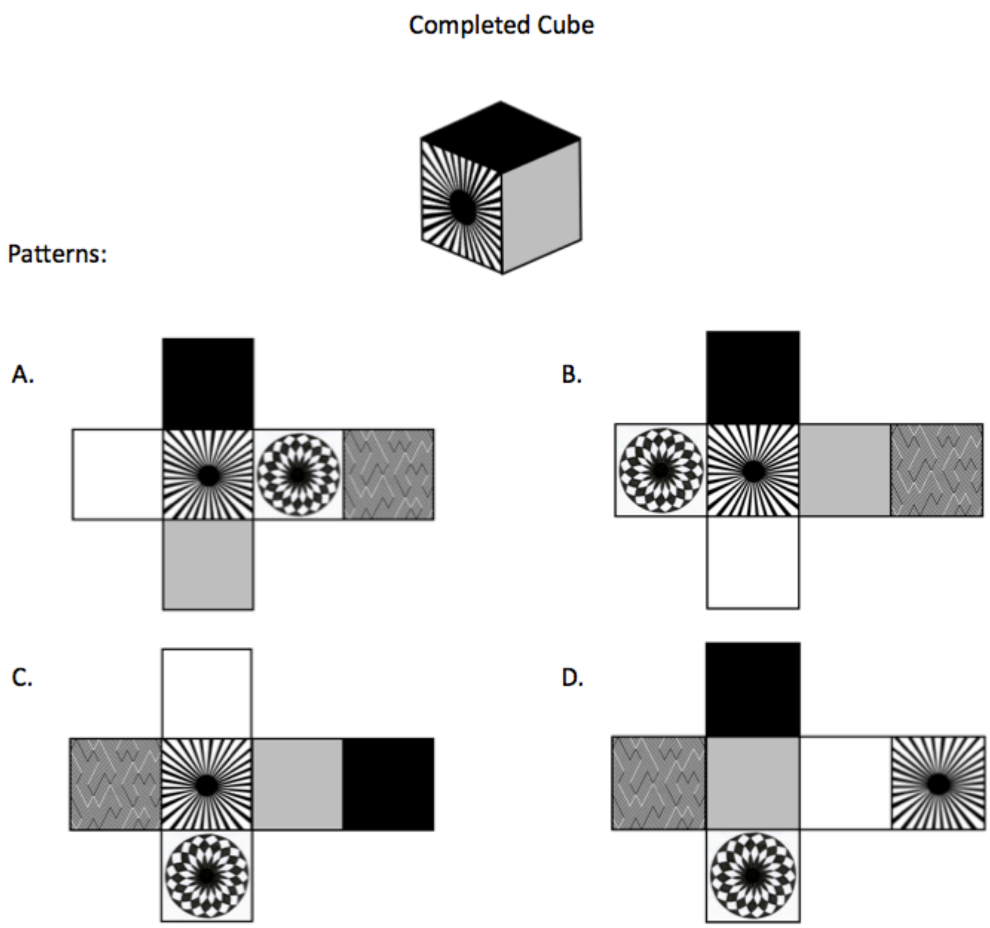
Studies show that a blend of virtual and physical models may be more advantageous than one or the other alone (e.g. Liu, 2006). Little research has been done on optimal sequencing of virtual/ physical models in classrooms, but Carmichael et al. (2010) found evidence that students may benefit from using a physical model prior to the virtual model.

Methods & Data

We use quasi-experimental methods to compare different sequencings. Half of students used the foam model first, then WWT. The other half used WWT first, then the foam model. We created identical pre/posttests that include multiple choice (MC) content questions about the Moon's phases, and open response questions that probe understanding. The former were selected from the Astronomy and Space Science Concept Inventory (ASSCI, Sadler, 2009), a compilation of

distractor-driven multiple choice questions. Open-response questions embedded throughout the activities were scored using a Knowledge Integration (KI, Linn, 2000) rubric.
We also included one “spatial skills” question asking students to identify which pattern would fold into the cube shown.

8. Which of the patterns when folded will make the cube shown?



E. None of the above

Results

Our results include data from the cohorts of students shown in Table 1.
For the cohorts where we have completed coding of the Open Response questions (A14, C14, and D14), we combined the multiple choice and open response scores for students in the pre and post assessment. Using OLS ANOVA, we found that the students’ pre-test answer on the spatial skills “cube” question was the only significant predictor of the post-test final score, other than the pre-test score. Model order is not a significant predictor of learning outcome. The results are presented in Table 2.

Table 1: Timeline and demographics for study. School X and School Y are both in the Greater Boston Area. School X is an urban school, and School Y is a suburban school.

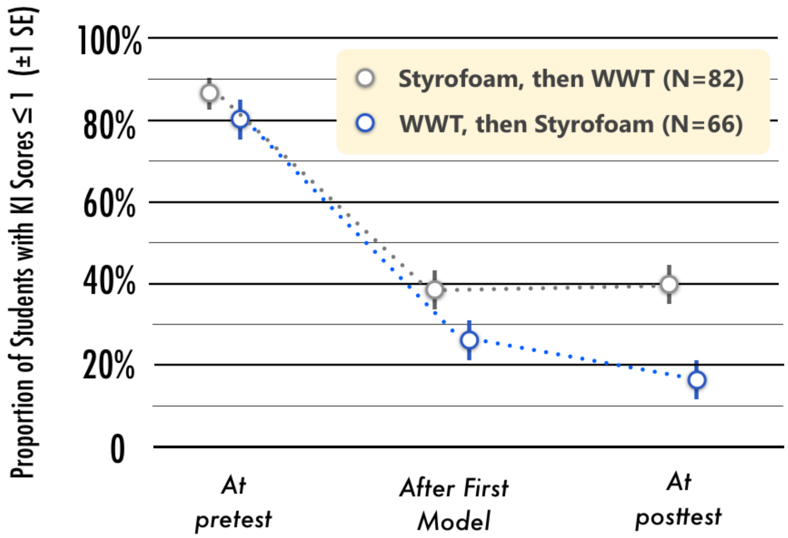
DATE	TEACHER	GRADE	SCHOOL	N STUDENTS		CODE
				Treatment 1	*Treatment 2*	
Apr 2013	A	8	X	$N_{Foam-WWT}$=40	$N_{WWT-Foam}$=28	A13
Dec 2013	B	6	Y	$N_{Foam-WWT}$=40	$N_{WWT-Foam}$=35	B13
Feb 2014	C	6	Y	$N_{Foam-WWT}$=34	$N_{WWT-Foam}$=37	C14
Mar 2014	A	8	X	$N_{Foam-WWT}$=42	$N_{WWT-Foam}$=38	A14
Oct 2014	D	6	X	$N_{Foam-WWT}$=38	$N_{WWT-Foam}$=37	D14

Table 2: OLS ANOVA results where the dependent variable is the Post-test score

VARIABLE	CATEGORIES	COEFFICIENT	STD. ERR.	T RATIO	PROB.
Constant		3.257	0.843	3.864	0.0001
Pre-test score		0.882	0.058	15.17	0.0001
Pre-cube question	incorrect	-0.396	0.1397	-2.833	0.0049
	correct	0.396	0.1397	2.833	0.0049
Model Order	Foam-WWT	-0.225	0.135	-1.674	0.0949
	WWT-Foam	0.225	0.1346	1.674	0.949

For cohorts where we have coded Knowledge Integration responses, most students (>80%) began the Moon Lab with a KI score ≤ 1, showing that misconceptions are common. Figure 2 shows that on the posttest, 18% of students who used WWT first have low KI scores, compared with 40% of students who used the Foam first.

Figure 2: **Students whose KI Scores Indicate Misconceptions or No Scientifically Valid Responses**



Significance

Our partner teachers suggested a learning progression where students make observations of the moon over a lunar cycle; recreate a lunar cycle using the styrofoam ball model; then deepen understanding by manipulating the computer model - i.e., they expressed a strong preference for using the foam model first. 81% of students also preferred or wished they had the styrofoam model first, or had no preference about model order. Yet we have some indication from our open response data, that students who had the less preferred order (WWT, then foam) ended the experience with fewer misconceptions. We hypothesize that this could be due to the realistic visualization providing students with a better foundation for understanding how to manipulate and use the physical model effectively. As this result contradicts existing research (Carmichael et al., 2010), this topic warrants further study.

References

Carmichael, A., Chini, J.J., Gire, E., Rebello, N.S., Puntambekar, S. (2010). Comparing the Effects of Physical and Virtual Experimentation Sequence on Students' Understanding of Mechanics. Paper at the Annual Meeting of the American Educational Research Association. Denver, April 30–May 4, 2010.

Linn, M.C. (2000). Designing the Knowledge Integration Environment. International Journal of Science Education 22, 781–796.

Liu, X. (2006). Effects of combined hands-on laboratory and computer modeling on student learning of gas laws: A quasi-experimental study. Journal of Science Education and Technology, vol. 15, pp. 89-100.

Sadler, P., Coyle, H., Miller, J.L., Cook-Smith, N., Dussault, M., Gould, R.R. (2009). The astronomy and space science concept inventory: Development and validation of assessment instruments aligned with the K–12 National Science Standards. Astronomy Education Review 8, 010111.