INSTITUTE for SCIENTIST & ENGINEER EDUCATORS

Instructor Guide for Choosing an Investigable Question Vignette

Institute for Scientist and Engineer Educators (ISEE)

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This paper was written and produced by the developers of the Professional Development Program (PDP) at the Institute for Scientist & Engineer Educators (ISEE) at University of California, Santa Cruz. The PDP was a flexible, multi-year program which trained participants to teach STEM effectively and inclusively at the post-secondary level. Participants were primarily graduate students and postdocs pursuing a broad range of science and engineering careers. Participants received training through two in-person multi-day workshops, worked on a team to collaboratively design an authentic, inclusive STEM learning experience (an "inquiry" lab), and then put their new teaching skills into practice in programs or courses, mostly at the college level. Throughout their experience, PDP participants used an array of online tools and received coaching and feedback from PDP instructors. The overall PDP experience was approximately 90 hours and was framed around three major themes: inquiry, assessment, and equity & inclusion. Leadership emerged as a fourth theme to support PDP teams, which were each led by a participant returning to the PDP for a second or third time, who gained training and a practical experience in team leadership. ISEE ran the PDP from 2001-2020, and there are more than 600 alumni.

CONTEXT FOR THIS PAPER WITHIN THE PDP

This guide is for instructors to use during workshops that use the "Choosing an Investigable Question Vignette." The Choosing an Investigable Question Vignette was used in the PDP to prepare participants for "facilitating" the inquiry activity that they designed. The term facilitation was used in the PDP for the small, in-the-moment moves an instructor makes to accomplish specific goals. This vignette was read by participants and then discussed in a workshop setting, prior to their teaching. The vignette, and the characters within it are fictional.

The PDP was a national program led by the UC Santa Cruz Institute for Scientist & Engineer Educators. The PDP was originally developed by the Center for Adaptive Optics with funding from the National Science Foundation (NSF) (PI: J. Nelson: AST#9876783), and was further developed with funding from the NSF (PI: L. Hunter: AST#0836053, DUE#0816754, DUE#1226140, AST#1347767, AST#1643390, AST#1743117) and University of California, Santa Cruz through funding to ISEE.

Instructor Guide for Choosing an Investigable Question Vignette

Line	Aim	Move	Missed Opp.	Comments
01	Nudge, push thinking forward	Drop materials, implicit suggestion		Get things moving, refocus,
03	Transfer ownership	Physically handling materials, handing them over		what are tradeoffs re: handing materials directly to each student vs. setting on table? (think dominant learner) But notice use of pronouns "I've got…"
07	Use materials to suggest process or comparison		Suggest alternative tool Introduce or suggest thermometer here?	incandescent bulbs get much hotter than "energy savers".
07	Manage dominant learner,		Fac does not respond to FS, could have her to restate question	(This was an early chance to get FS student more involved, but facilitator response to Male student.
07	Redirect, scaffold steps to hypothesis testing,	feign confusion, ask clarifying question (why would that matter)		Depending on ***tone*** this could be dismissive or inviting.
10	Focus investigation, prevent going to a dead end		Nods in agreement and affirms MS assertion but could have said something to redirect focus	In line 09 the MS was getting slightly off track. Facilitator could have done more to challenge or make accessible his thinking about the coating

Instructor Guide for Choosing Investigable Question Vignette (cont.)

Line	Aim	Move	Missed Opp.	Comments
10	Recognize contribution	affirmation "Yeah good point"		different gases are actually nearly impossible to tell the spectrum of given the white phosphor coating on the bulb.
10	Redirect approach, challenge thinking	Suggest material; Have you seen tubes?		This is a subtle suggestion to make a comparison
10	Redirect approach, challenge thinking		Facilitator could have first paraphrased male student's proposition, but then asked a follow up question,	Could have indicated a bulb that would be worth comparing, or suggested a thinking tool or some way to pursue that thought further
12	Recognize contribution; Redirect, scaffold steps to hypothesis testing	Suggest materials: How can you use uncoated tubes?		Question affirms that student question is a valid and investigable question, but also prompts starting investigation pathway. Also provides recognition.
14	Making thinking accessible	Follow-up question (what makes you think that)		Also helps learners with metacognition; reflect on prior knowledge consider if it is grounded in evidence

Line	Aim	Move	Missed Opp.	Comments
14	Making thinking accessible, scaffold hypothesis testing		Could have responded more directly to FS to provide more support understanding how coating factors in to what is ultimately investigable.	light emitting from gas (argon) is not visible, luminance depends on phosphor coating. Students need to realize they can't get a direct measurement.
14	Support non-dominant learner		Didn't respond to FS directly, instead open suggestion to explore uncoated bulbs was in response to MS	Good opportunity to recognize FS; BUT this is probably a tension many facilitators struggle with. Giving to much direction vs. suggesting possible investigation pathways
16	Affirmation, provides recognition	restates observation, paraphrase "Like you both noticed"		Also serves to refocus investigation while acknowledging individual contributions
17	ownership	Provides Wait time		This is apparent "non-move" could actually be considered a productive move (wait time) by the facilitator who is showing restraint, not trying to control the situation and let the students take the lead

Instructor Guide for Choosing Investigable Question Vignette (cont.)

Line	Aim	Move	Missed Opp.	Comments
19	Refocus investigation	Feign confusion + Pivot move "what is the goal here"		Students hadn't yet formulated a plan
21	Recognition; refocus investigation		Could have paraphrased to reaffirm FS approach. This is actually more than a MO it is a misstep by the facilitator. The FS idea is actually better than what FAC indicates.	switching the wattage of the bulbs is not helpful since we don't know if all the other properties of the bulbs are fixed So, moral of the story with this misstep is that sometimes the inclination of a facilitator to keep suggestion more options is not always the best path.
23	Acknowledge non-dominant learner contribution		Does not respond directly to FS question	This could have been a place for formative assessment, to try to draw out "make visible" what the student understood at the time about the concepts of voltage and wattage and how they are related.
24	Make thinking accessible , promote ownership		"yeah that's right" Classic MO, affirmation instead of drawing out student thinking	Evaluative statement could have been replaced by follow-up question

Instructor Guide for Choosing Investigable Question Vignette (cont.)

Line	Aim	Move	Missed Opp.	Comments
26			Laughter (Fac could have reinforced his suggestion to try indirect methods)	Not clear that students understand that indirect investigations are worthwhile also
26	Encouraging collaboration and strong team dynamic	encourage laughter		Laughter/humor can create valuable social atmosphere. Facilitator could have shown disdain towards the joke
32	Recognition of learner unique contribution		not acknowledging that FS first asserted what MS student says	
			Feigns confusion when he could have made a suggestion	Could have moved closer to collaborative role instead of instructor, "sly" mode.
32	Expose partial, alternative, misconceptions.	Pivot move, redirect		Second half of statement "So - what is happening when you reduce the voltage allowed to power the light bulb?

Instructor Guide for Choosing Investigable Question Vignette (cont.)

Line	Aim	Move	Missed Opp.	Comments
33	Making thinking accessible, formative assessment of content learning.		Could have asked for a prediction or asked a clarifying question	This is very a valuable teachable moment in that the student is making his conceptual thinking about current and voltage accessible to the facilitator, so it presents a good opportunity to help him refine his thinking.
34	ownership, while supporting hypothesis testing		good opportunity to remind students that color filters are available to test this question from FS	FAC had mentioned above that these were available but students didn't seem to take much notice.
35	Transfer of ownership, Recognition	Validation; "You should test that…"		Validating learner approach without taking away ownership. Nice that Fac is (finally) acknowledging FS contribution

Line	Aim	Move	Missed Opp.	Comments
39	Focus investigation		Introduces possible investigation path but does not follow-up to see if actually viable. Could have helped them returned to their earlier hypothesis which was testable - namely that by increasing the voltage you are not changing the wavelength.	Facilitator made potentially productive move by hinting at a indirect investigation pathway. But What is the function of laughter that follows? Does it indicate that learners are not really understanding?
40	Creating collaborative work atmosphere		missed opportunity after laughter--could have explored different ways regarding validity of indirect investigation	Is this indicative of testing invisible norms considered to be valid scientific practice?

Line	Aim	Move	Missed Opp.	Comments
41	Transfer Ownership while reinforcing focus on hypothesis testing	Restate / summarize		"But you also had another hypothesis, something to do with the spectra, right? By phrasing this summary as a question the facilitator attempts to put the ball right back in their court. However this is tricky because Students could immediately pick up on that as him giving away the "answer"
42	Focus investigation		Possible Misstep questionable whether this is the right time to introduce another piece of equipment	a viable investigation pathway has just been established. Giving more options could cause confusion. Worth discussing how the utility of any move is always contingent on what is happening in the moment rather than any move being ultimately "bad" or "good"

Additional technical notes:

- **(Relevant to line 21 where Facilitator actually makes a misstep)** The way the incandescent bulbs really work is that the current simply heats the filament up so hot that it glows with thermal radiation. That's why they're relatively energy inefficient: you have to get them really hot so they glow bright enough and blue enough to be seen. So I guess the thermometers could be used to tell that as the bulb is cranked brighter, it will get hotter. But if you change from one wattage bulb to another, the specific alloys of the filaments might change and so it's hard to control all the variables. Better to test this part with a single bulb run at different voltages
- **(Relevant for MS statement in line 33)** All matter with a temperature greater than absolute zero emits thermal radiation. Thermal radiation is electromagnetic radiation generated by the thermal motion of charged particles in matter. All matter with a temperature by definition is composed of particles which have kinetic energy, and which interact with each other. These atoms and molecules are composed of charged particles, i.e., protons and electrons, and kinetic interactions among matter particles result in charge-acceleration and dipole-oscillation. This results in the electrodynamic generation of coupled electric and magnetic fields, resulting in the emission of photons, radiating energy away from the body through its surface boundary. This results in charge-acceleration and/or dipole oscillation which produces electromagnetic radiation, and the wide spectrum of radiation reflects the wide spectrum of energies and accelerations that occur even at a single temperature.
- **(Relevant for lines 33-35)** Fluorescent bulbs works differently than incandescent which change color to reflect change in temperature. Fluorescents aren't dimmable at all, so changing the voltage is just going to turn it off or on, but once on its properties won't really change. What will happen with an incandescent is that if it is brighter it will also be bluer (this is related to "color temperature" in photography white-balance, and sort of related to the difference between "soft white" and "day light" color bulbs).
- **(Relevant to Line 42)** Introduction of the thermometer could have waited, first they could investigate voltage/brightness/spectrum relationships, then later added temperature as a new variable. Now the facilitator takes the momentum away from what just happened by bringing this new thing in.