The use of cognitive task analysis to inform the development of a laboratory course in chemistry

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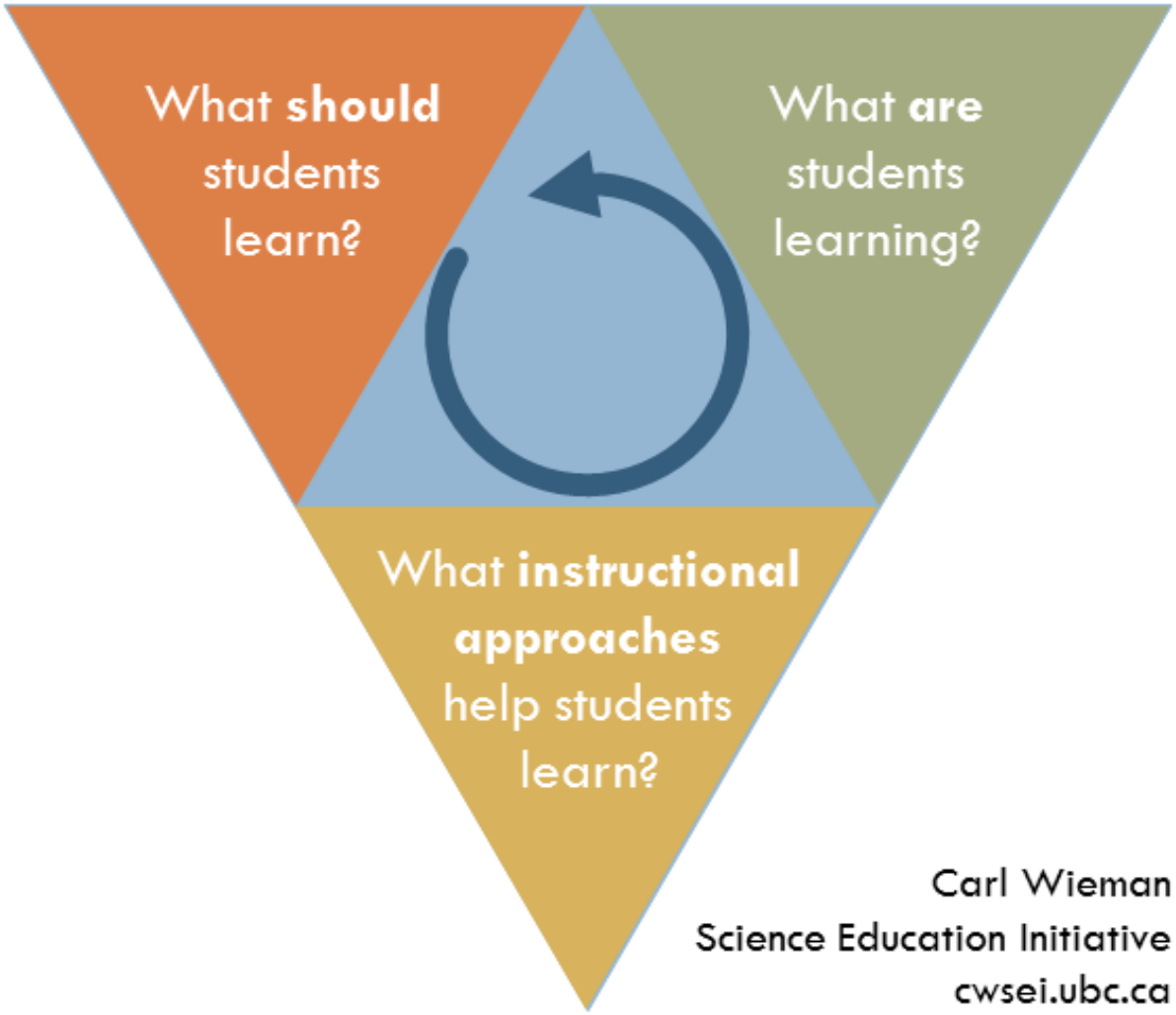
The Carl Wieman Science Education Initiative



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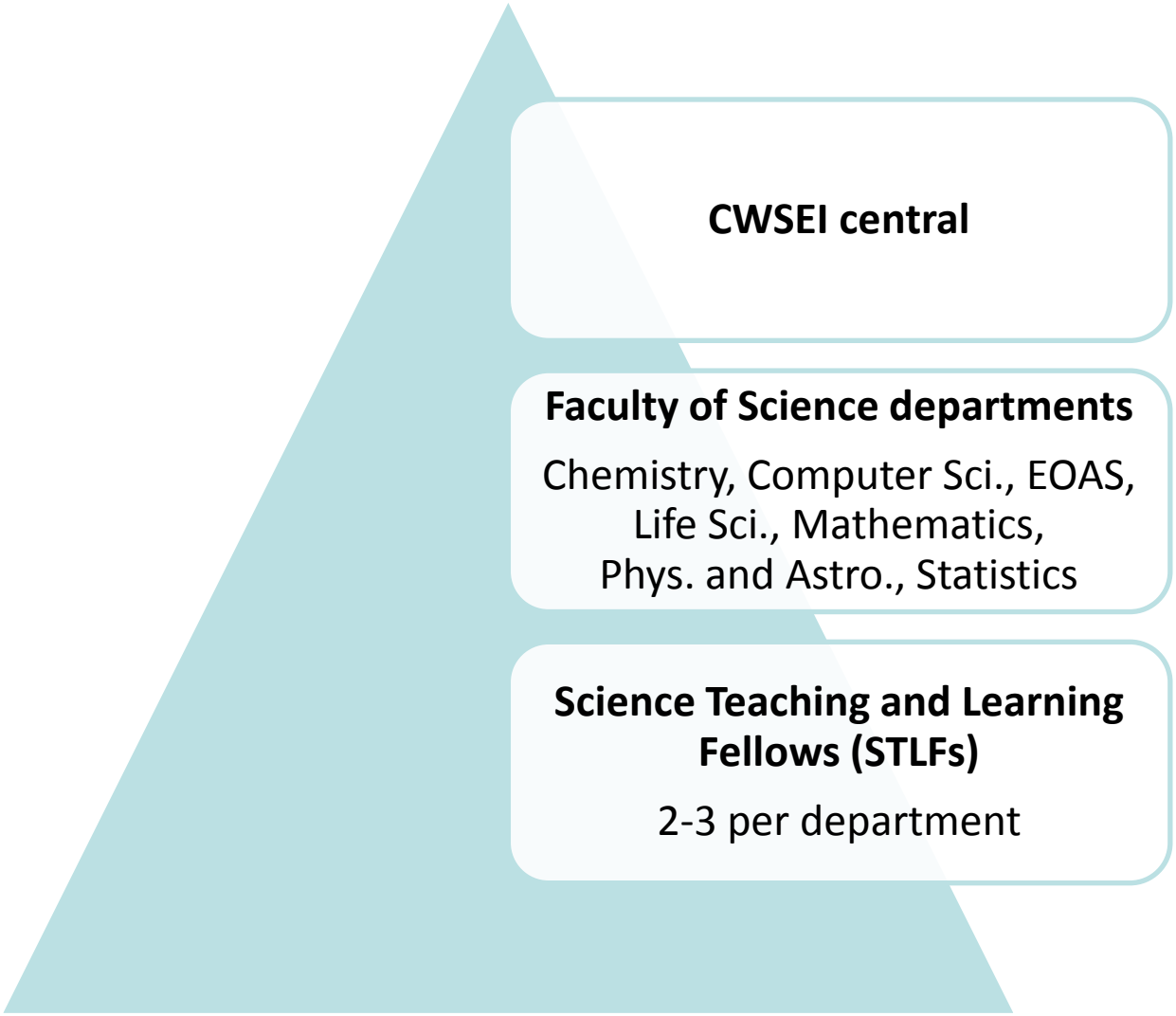

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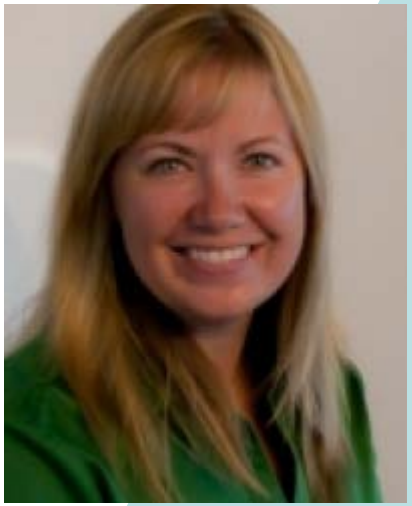


CWSEI central

Faculty of Science departments

Chemistry, Computer Sci., EOAS, Life Sci., Mathematics, Phys. and Astro., Statistics

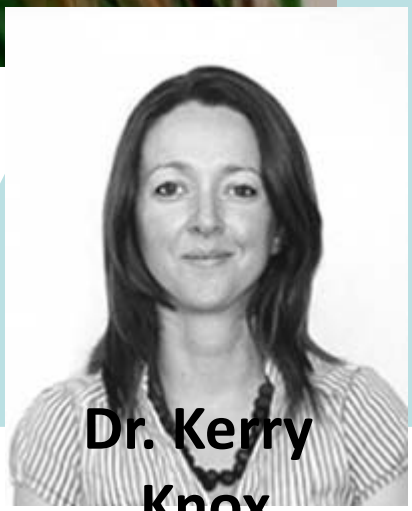
Science Teaching and Learning Fellows (STLFs)

2-3 per department

The Carl Wieman Science Education Initiative

Dr. Jackie Stewart

Dr. Jane Maxwell



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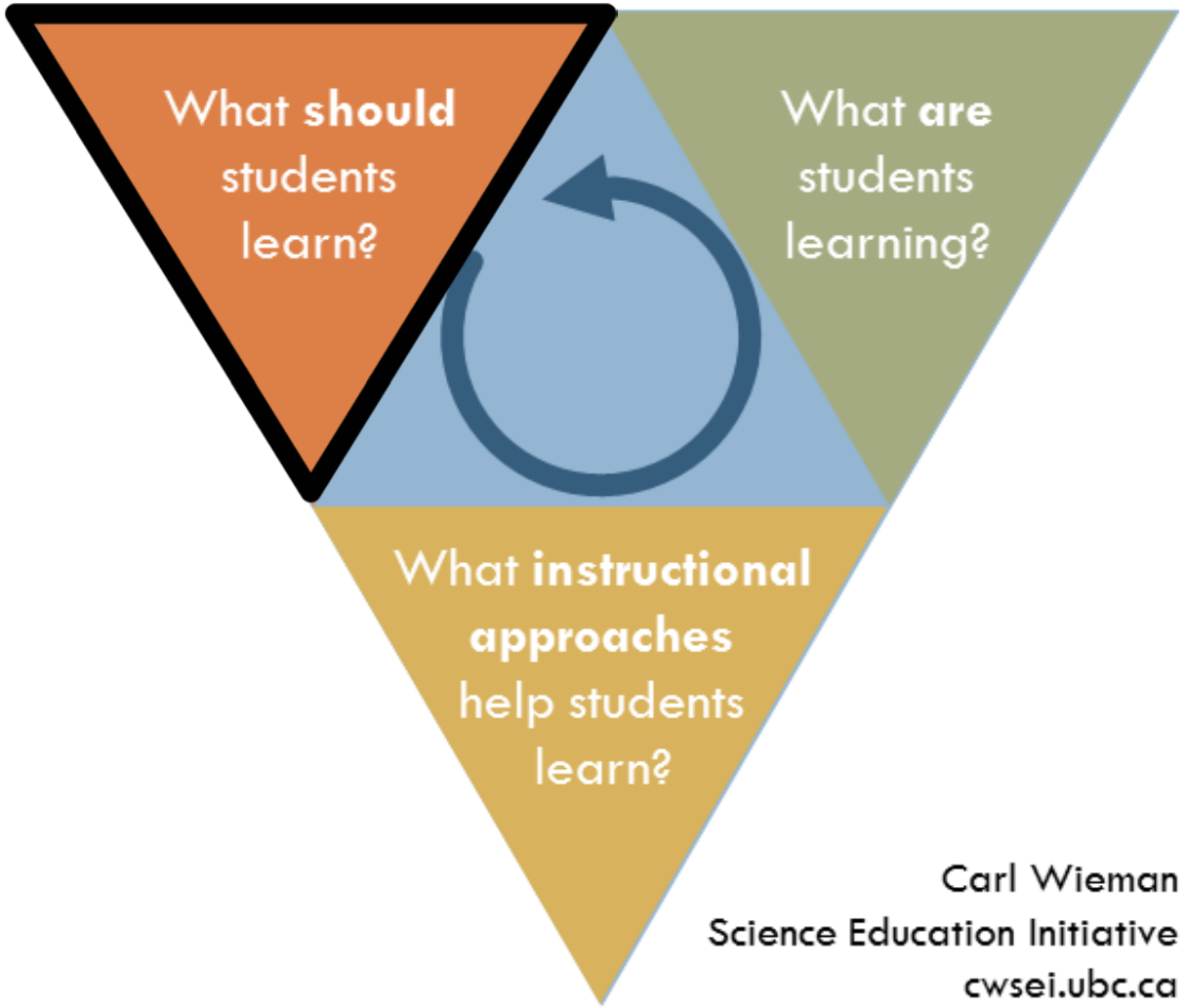
The third-year integrated chemistry laboratory course at UBC; "CHEM 3XX"

- Comprises all of the third-year instruction in experimental chemistry
- ~350 students
- Recently integrated to bring four distinct lab courses into one (analytical, inorganic, organic and physical)
- Students create their own course by selecting the experiments they will complete

The CHEM 3XX instructional team

Dr. Guillaume Bussiere	Physical
Dr. Vishakha Monga	Inorganic
Dr. José Rodríguez Núñez	Materials
Dr. Christine Rogers	Organic
Dr. Robin Stoodley	Analytical

Goal: To align the course with findings from research on learning



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Cognitive task analysis as a way to frame a discussion about what students should learn

- **What should students learn?**

Common philosophy

- High content undergraduate experimental chemistry
- Increasing number of techniques for students to master

Alternative approach

- Prioritize common ***cognitive tasks*** involved in experimental research
- Acknowledge and accept that new techniques will have to be learned “on the job”

The process that we followed

- Start from Carl Wieman's cognitive task analysis for experimental research…

1. Establishing research goal

c. Evaluating whether the research question is consistent with the constraints on funding, equipment...

4. Experimental design

a. Exploration of many possible preliminary designs

d. Developing detailed data acquisition strategy

7. Evaluating results

a. Checking the results when they differ from expected

C. E. Wieman, "Cognitive tasks involved in carrying out experimental research"

The process that we followed

- Ask the following question about each lab. expt.:

"Does this experiment move students toward these ways of expert-like thinking?"

Yes (Y)

No (N)

not applicable (NA)

C. E. Wieman, "Cognitive tasks involved in carrying out experimental research"

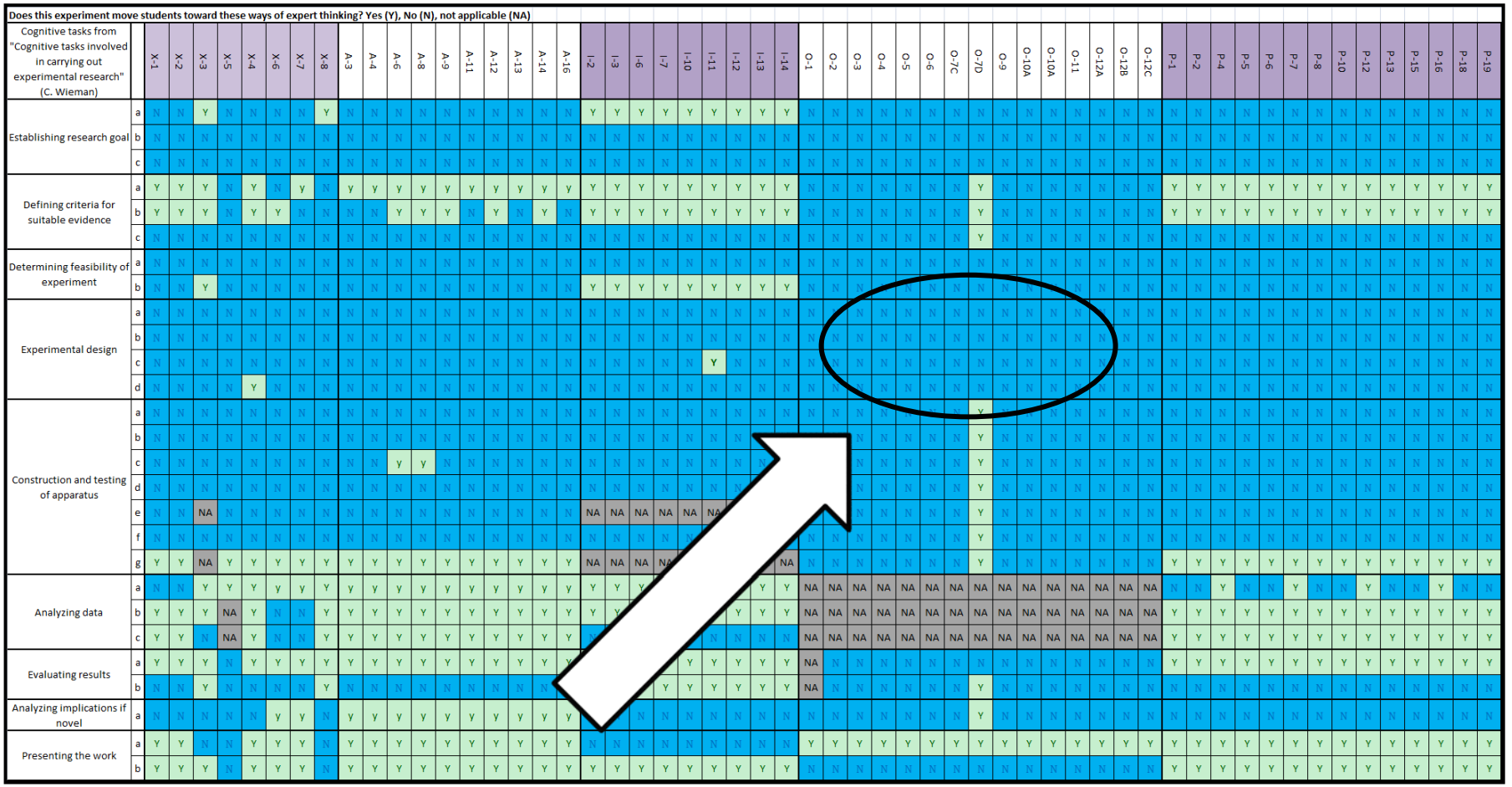
The product of the process

experiments/labs.

cognitive tasks

Does this experiment move students toward these ways of expert thinking? Yes (Y), No (N), not a													
Cognitive tasks from "Cognitive tasks involved in carrying out experimental research" (C. Wieman)		X-1	X-2	X-3	X-5	X-4	X-6	X-7	X-8	A-3	A-4	A-6	A-8	A-9
Establishing research goal	a	N	N	Y	N	N	N	N	Y	N	N	N	N	N
	b	N	N	N	N	N	N	N	N	N	N	N	N	N
	c	N	N	N	N	N	N	N	N	N	N	N	N	N
Defining criteria for suitable evidence	a	Y	Y	Y	N	Y	N	y	N	y	y	y	y	y
	b	Y	Y	Y	N	Y	Y	N	N	N	N	Y	Y	Y
	c	N	N	N	N	N	N	N	N	N	N	N	N	N
Determining feasibility of experiment	a	N	N	N	N	N	N	N	N	N	N	N	N	N
	b	N	N	Y	N	N	N	N	N	N	N	N	N	N

The product of the process



area of focus for 2014/15

Arising from the process

<u>Focusing the development efforts; prioritizing the learning goals</u>

- Experimental design in organic chemistry experimental design

Translation of CTA to this context...

- Addressed through interview and consulting literature:

- ***Identifying range of suitable synthetic procedures***
- ***Comparing and choosing between literature syntheses***
- ***Choosing procedures given certain constraints – a "reagent landscape"***
- ***Iteration of procedure chosen depending on outcome***

D. L. Lafarge *et al*., *Journal of Chemical Education*, 2014, **91**, 173

Arising from the process

Guiding the design of the learning activities

*Initiation of a 4-hour workshop ("dry lab") to address learning goals:

"Given a starting material and target product, students will be able to:

- ***Identify a range of known synthetic procedures relevant to the problem at hand using SciFinder, ChemSpider and/or reference texts as appropriate***
- ***From the plausible procedures identified determine which would be most appropriate to use given certain constraints, for example time available, availability of reagents...***
- ***Use knowledge of the composition of a product mixture to suggest improvements to synthetic procedures***

*Through scaffolded learning activities, peer instruction and increased opportunity for expert-novice interactions

In summary...

Cognitive task analysis as an approach to:

- Framing conversations around role and goals of courses in experimental science
- Focussing of development efforts
- Informing the design of learning activities

Acknowledgements

Dr. Jackie Stewart	Director: CWSEI in Chemistry
Dr. Ido Roll	Mapping inspiration and guidance
Drs. G. Bussiere, V. Monga, J. Rodríguez Núñez, C. Rogers, R. Stoodley	Mapping of cognitive tasks (instructional team)
Dr. Greg Dake	Organic synthesis expertise