What is a concept inventory?

A balloon containing nitrogen gas at 40 °C is cooled down to 10 °C and it becomes smaller. Assuming that no nitrogen gas can escape the balloon and that the external pressure remains constant, which statement below best explains why the balloon becomes smaller?

a) When cooled, the nitrogen molecules exert less force on the inside of the balloon so the volume decreases until the internal pressure is the same as the external pressure.

b) Upon cooling, the nitrogen molecules become denser and spend more time near the bottom of the balloon.

c) When cooled, the nitrogen molecules become smaller and they occupy less volume so the balloon becomes smaller.

d) Upon cooling , the attractive forces between the nitrogen molecules increase which causes the molecules to group together and occupy less volume.

e) None the of above explanations accurately explain why the balloon becomes smaller.

What are concept inventories used for?

To compare the effectiveness of different teaching methods and approaches.

To identify the students' conceptual strengths/weaknesses.

To provide feedback on the level of student preparation to instructors and students.

To determine the knowledge gain for the class and for individual students.

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Our goals

To develop a chemistry concept inventory that is appropriate for Ryerson, Ontario universities, and later, other Canadian universities.

Considerations:

Topics should be selected from within the defined curriculum of the Grade 11U/12U classes in Ontario.

Topics must also be covered in first year chemistry classes.

Multiple questions should evaluate each topic to check for consistency (preferably at different levels of difficulty).

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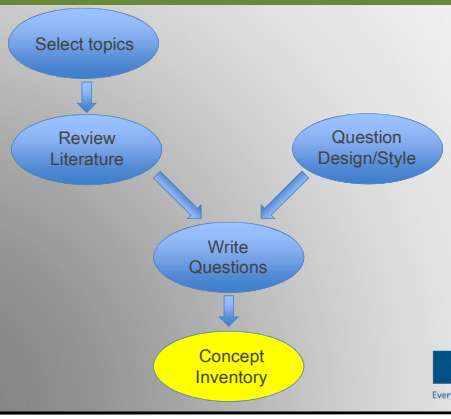
Developing the inventory



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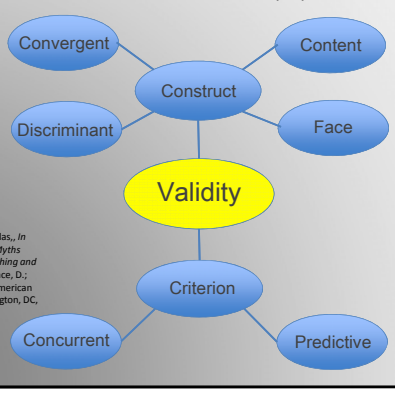
Evaluating the inventory: Validity

"Does the instrument measure what it is purported to measure?"



J. Barbera and J. Vandenplas,, *In Investigating Classroom Myths through Research on Teaching and Learning*, Chapter 11; Bunce, D.; ACS Symposium Series; American Chemical Society: Washington, DC, 2011.

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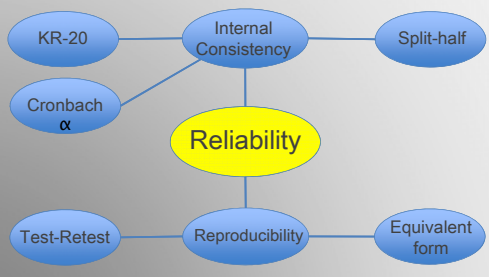
Evaluating the inventory: Reliability

"An assessment of the random error in an instrument's data"



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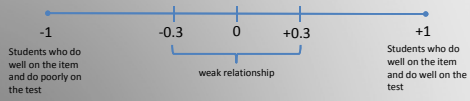
Evaluating the inventory: Item assessment

Things to consider:

Difficulty: How "hard" was the question. Sometimes reported as the % of students selected the correct answer.

Discrimination: The relationship between passing/failing an item and doing well/poorly on the test. Sometimes reported as a value between -1 and +1.



Response frequencies: The number of students who picked each answer option for an item.

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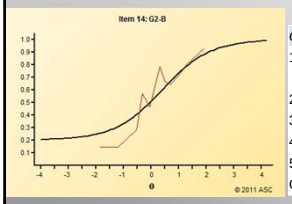
Evaluating the inventory: Our example item



Option Statistics

Option	N	Prop.	S-Rpbis	SD	
1	105	0.488	0.252	1.788	KEY
2	21	0.098	-0.143	1.963	
3	22	0.102	-0.140	3.040	
4	46	0.214	0.025	2.863	
5	14	0.065	0.014	2.994	
Omit	7	0.033	-0.308	3.111	

IRT Parameters

a	b	c	a SE	b SE	c SE	Chi-sq	df	p	z Resid	p
1.170	0.356	0.201	0.250	0.183	0.179	7.689	19	0.990	0.201	0.841

Classical Statistics

N	P	S-Rpbis	T-Rpbis	Alpha w/o
215	0.488	0.252	0.392	0.568

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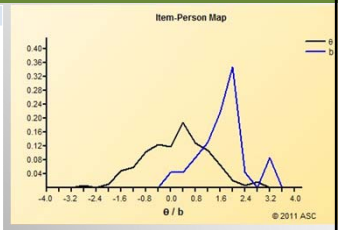
Evaluating the inventory: Overall results

Seq.	Item ID	P	R	a	b	c
1	H1-B	0.609	0.123	0.874	-0.190	0.207
2	H2-B	0.316	0.139	1.063	1.815	0.206
3	H3-B	0.377	0.097	1.007	1.476	0.216
4	H4-A	0.335	0.222	1.316	1.254	0.198
5	H5-B	0.279	-0.010			
6	H6-A	0.437	0.138	0.910	0.907	0.204
7	E6-A	0.367	0.382	1.632	0.757	0.188
8	E2-B	0.451	0.138	0.937	0.848	0.210
9	E3-B	0.302	0.192	1.188	1.670	0.199
10	E4-B	0.102	0.132	1.642	2.934	0.152
11	E5-A	0.228	0.104	1.404	2.231	0.193
12	E6-B	0.326	0.098	1.040	1.797	0.210
13	G1-B	0.298	0.072	1.266	1.895	0.212
14	G2-B	0.488	0.252	1.170	0.356	0.201
15	G4-A	0.307	0.149	1.023	1.870	0.203
16	G5-C	0.233	0.159	1.440	1.953	0.188
17	G6-B	0.251	0.344	1.593	1.436	0.179
18	G7-C	0.367	0.284	1.466	0.877	0.195
19	S1-C	0.102	-0.005	1.710	3.111	0.155
20	S2-C	0.302	0.107	1.113	1.838	0.205
21	S3-C	0.456	0.290	1.129	0.559	0.200
22	S4-B	0.298	0.354	1.433	1.209	0.184
23	S5-A	0.260	0.110	1.366	1.907	0.199
24	S6-B	0.286	0.303	1.599	1.281	0.185



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Evaluating the inventory: Think aloud interviews

Statistics highlight the problematic questions, but don't tell us anything about **WHY** the questions are problematic.

What we learned:
- Some of our questions were too 'wordy' and/or confusing.
- The cognitive load of some questions was too high.
- Some students are reluctant to select answer options such as
  - None of the above
  - Not enough information….

AND

In some cases, the students really don't understand the concepts!

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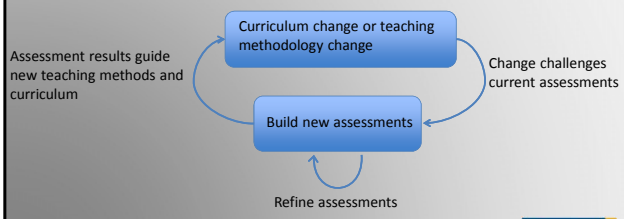
Final thoughts

- Regarding our inventory
- Regarding concept inventories
- Regarding use of assessment in curriculum reform



Holme, T. et al, "Enhancing the role of assessment in curriculum reform," *Chem. Educ. Res. Pract.* 2010, **11**, 92-97.

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Acknowledgements

Collaborators
- Dr. Andrew McWilliams
- Dr. Olesya Falenchuk (OISE)

Students
- Mihailo Aleksandric
- Marek Koloszyc
- Kinjal Naik
- Natalia Mnich

Intrigued?

If you are interested in participating in the development of additional RCCI modules please contact Dr. Noel George (n3george@ryerson.ca) or Dr. Andrew McWilliams (amcwilli@ryerson.ca) for more information

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Some useful resources for learning about Item Response Theory (IRT)

A great book to start with (and free!) is Frank Baker's "The Basics of Item Response Theory." It is not super long and it is very easy to read. You can download it for free (see link in left hand menu) from: http://echo.edres.org:8080/irt/baker/

Once you get through that a good follow up is Christine DeMars "Item Response Theory". DeMars, C. (2010).Item Response Theory. New York: Oxford University Press. This book is also fairly short and concise. The Ryerson library actually has this so if your library doesn't you may be able to get it through interlibrary loan.

Other IRT intros worth checking out:

Karen F. Cook has a six-part series of youtube videos that I watched recently. They are a nice introduction and she has an interesting sense of humour.
http://www.youtube.com/playlist?feature=c4-feed-u&list=PLJNUIJnElUzDmrIPunMyF3tTvIHb65wNb

IRT: A multimedia tutorial: http://www.creative-wisdom.com/multimedia/IRTTHA.htm

A visual guide to IRT: http://www.metheval.uni-jena.de/irt/VisualIRT.pdf

The national council on measurement in education (NCME) puts out a series of articles that are quite good. I like this one by Hambleton and Jones "Comparison of Classical Test Theory and Item Response Theory and Their Applications to Test Development" It can be found online here: http://testolog.narod.ru/IRT3.pdf