SMEC 2014

Does an Inquiry Based Learning Approach, merged with Modelling and Visualisation, to the teaching of the Particulate Nature of Matter lead to the Transformative Education of early secondary school students?

Enda Carr

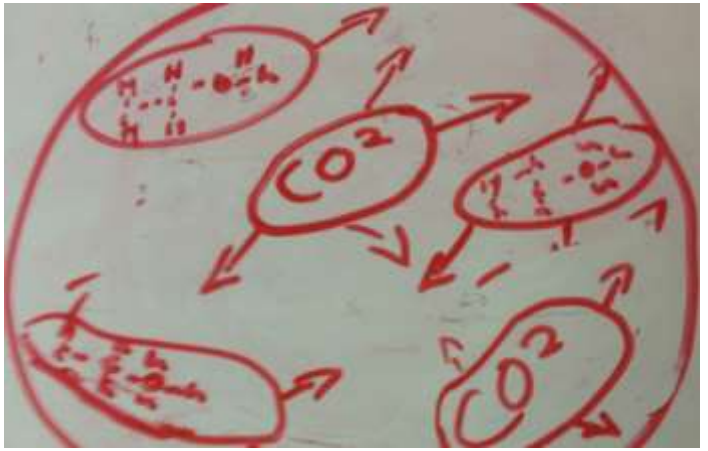
Objectives

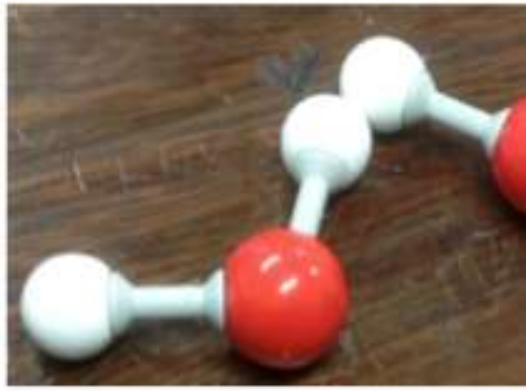
- Action Research supported by Personal Construct Psychology (PCP) to advance learning
- Inquiry Based Learning supported by PCP to identify learning gaps
- Quantitative evidence of learning advancement
- Conclusion

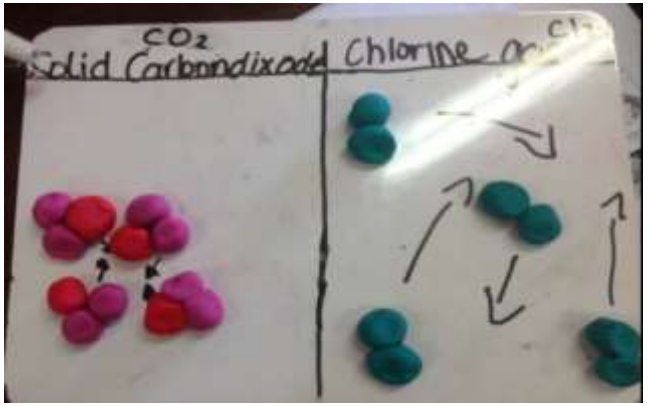
What is meant by Modelling / Visualisation?

- Written text, diagrams, cartoons, images, photographs and models (static pictorial)
- Computer programs, drama and acting out a process (dynamic pictorial) - Waldrip, Prain and Carolan's (2006)
- Molecular modelling programs, physical models e.g Play-Doh - Jones, Jordan and Stillings (2005)
- Simulations - Mayer and Moreno (2002)

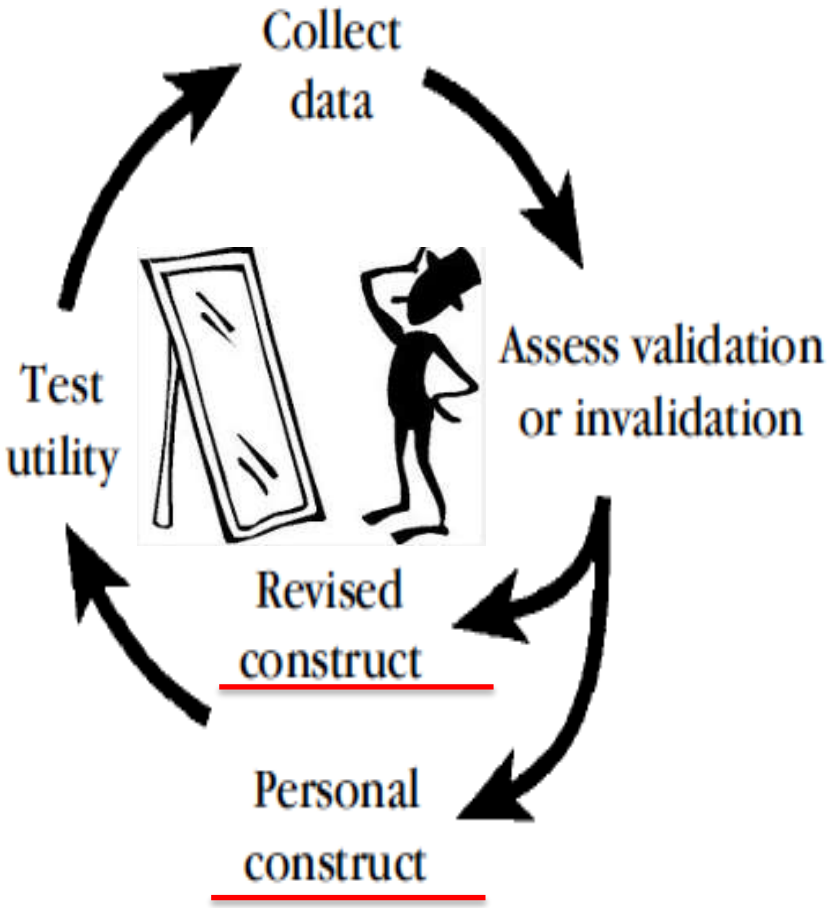
What is meant by Modelling / Visualisation?



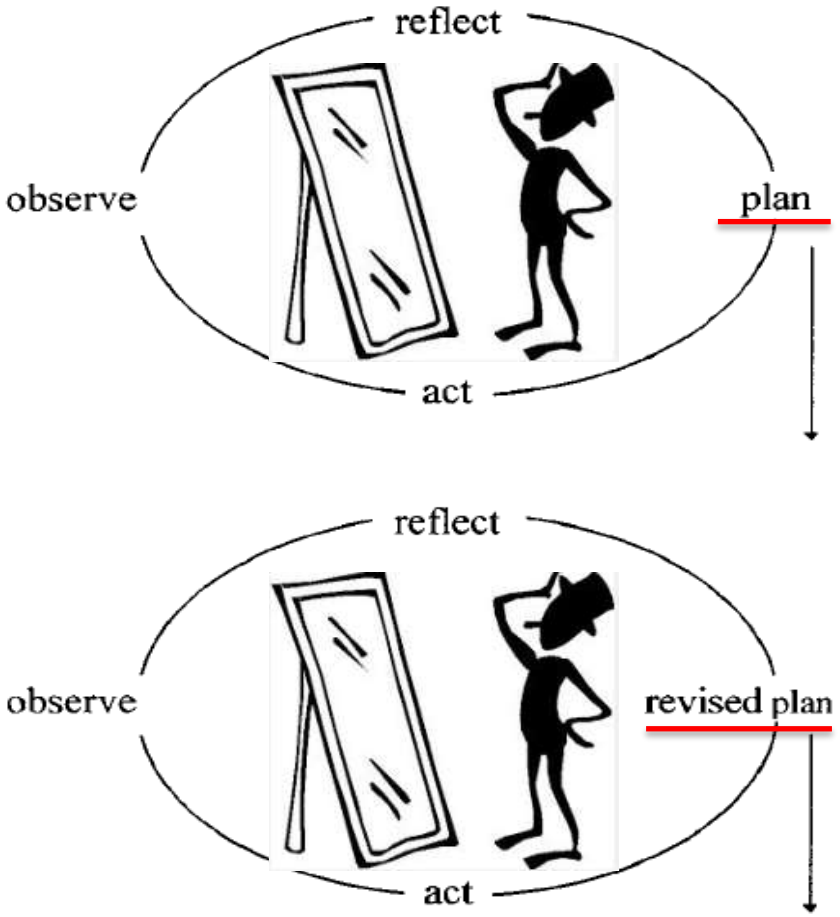




Action Researcher as a Personal Scientist Model



Kelly's Personal Scientist Model
Source: Kelly (1955 / 1991)

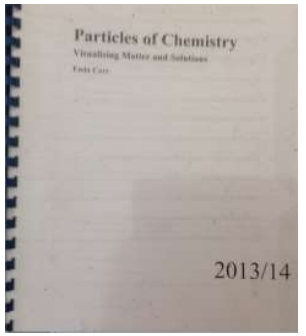


Action Research Spiral Kemmis and McTaggart (1982)

Action Researcher as a Personal Scientist

Data Collection

Formative /
Summative Exams

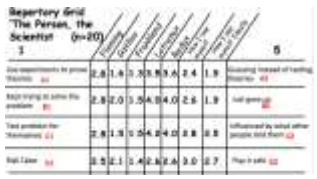


Workbook

**Teacher/
Student
(Personal
Scientists)**

Teacher
Learning
Journal

Student
Input
Repertory
Grid



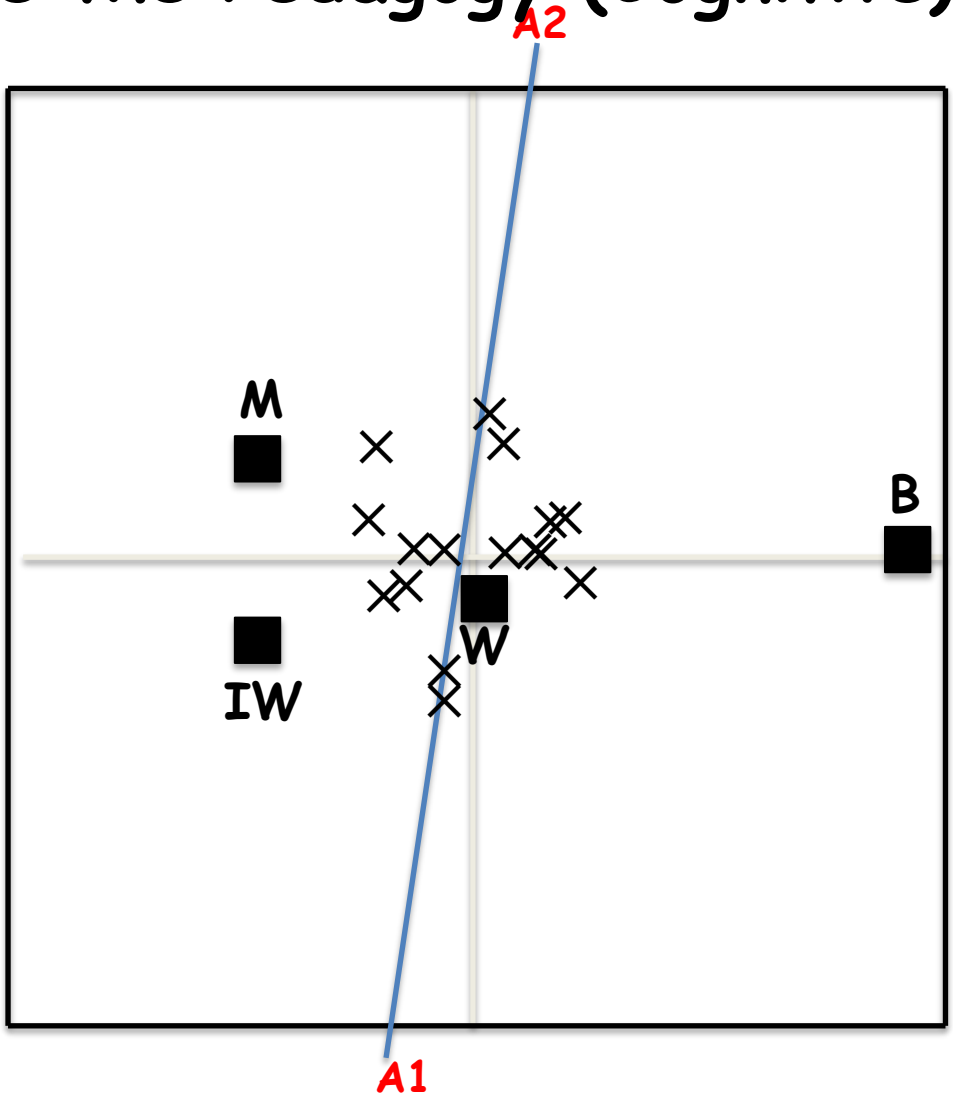
Repertory Grid 2013
Pedagogy – Cognitive
(n=20)

1Preferred Pole	Modelling	TextBook	Work Book	How I would like to see this workbook	Negative Pole 5
Models look Realistic A1	2.6	2.4	2.1	1.8	Molecules are not represented properly A2
Gives a visual aid that tells me what a molecule is like B1	1.8	2.3	2.0	1.8	Can't picture what a molecule looks like B2
I can see how states of matter behave C1	2.0	2.2	1.7	1.6	I don't really know how states of matter behave C2
Working in groups allows me to see what others are thinking D1	1.8	2.6	2.3	1.7	I only have my opinion D2
I get to make my own notes and drawings E1	2.0	3.1	2.1	2.0	Just given notes that i might want to word differently E2
Allows me to express my own way of understanding F1	1.5	3.1	2.2	1.6	Just given the information and i have to give it back exactly F2
I actually get to figure things out for myself G1	2.0	3.2	2.4	1.8	I just look at and read the information that is given G2
Allows me to think about what I have learned so that I can understand and remember H1	2.0	3.0	2.4	2.0	I just read over someone else's thoughts H2

Repertory Grid
Pedagogy - Cognitive

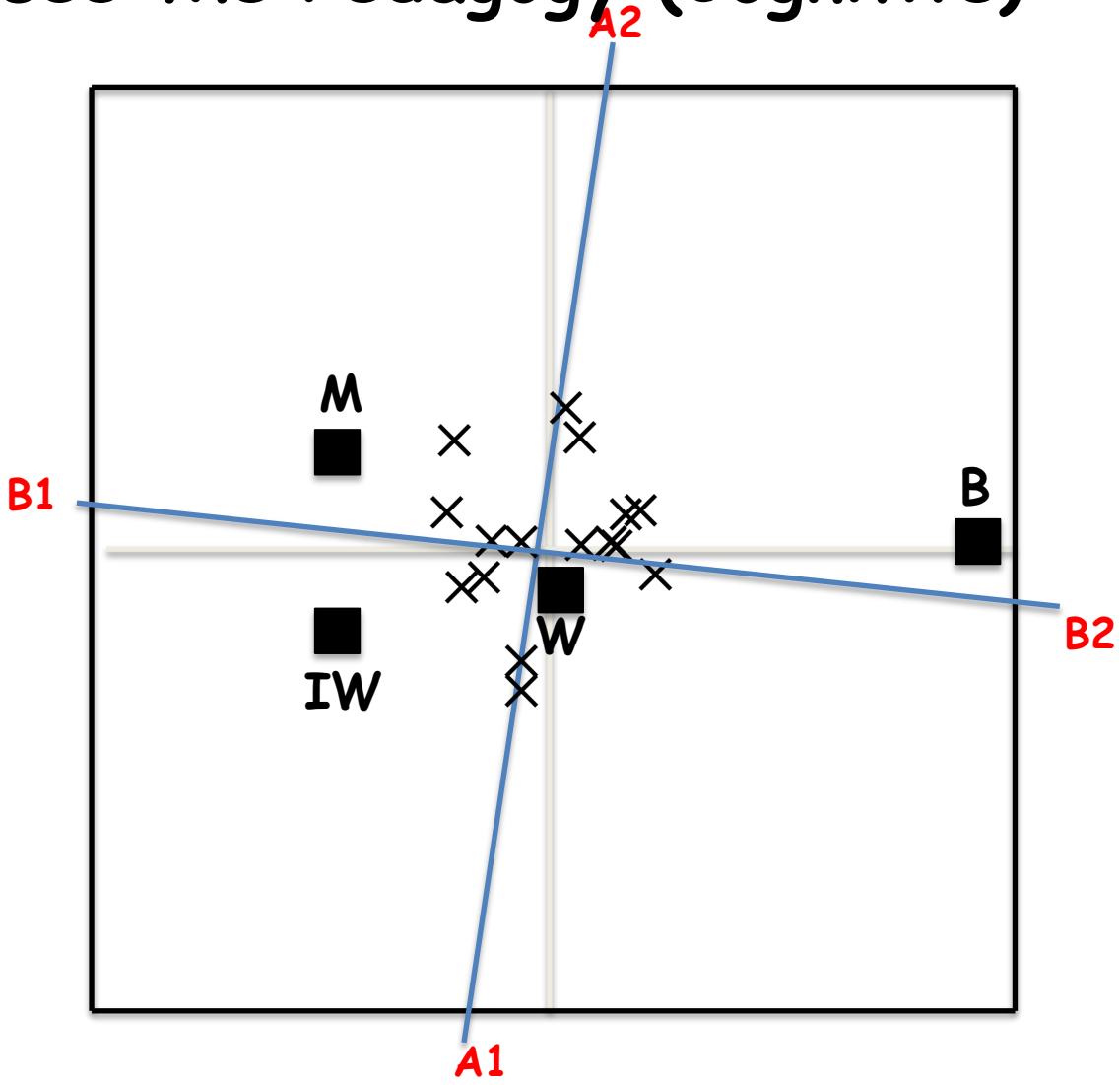
1	Modelling	Book	Work Book	How I would like to see this workbook	5
I understand better if i make or model something **I1**	1.6	3.2	2.3	2.0	Just learn off notes and pictures **I2**

Principal Component Analysis: How I see the Pedagogy (Cognitive)



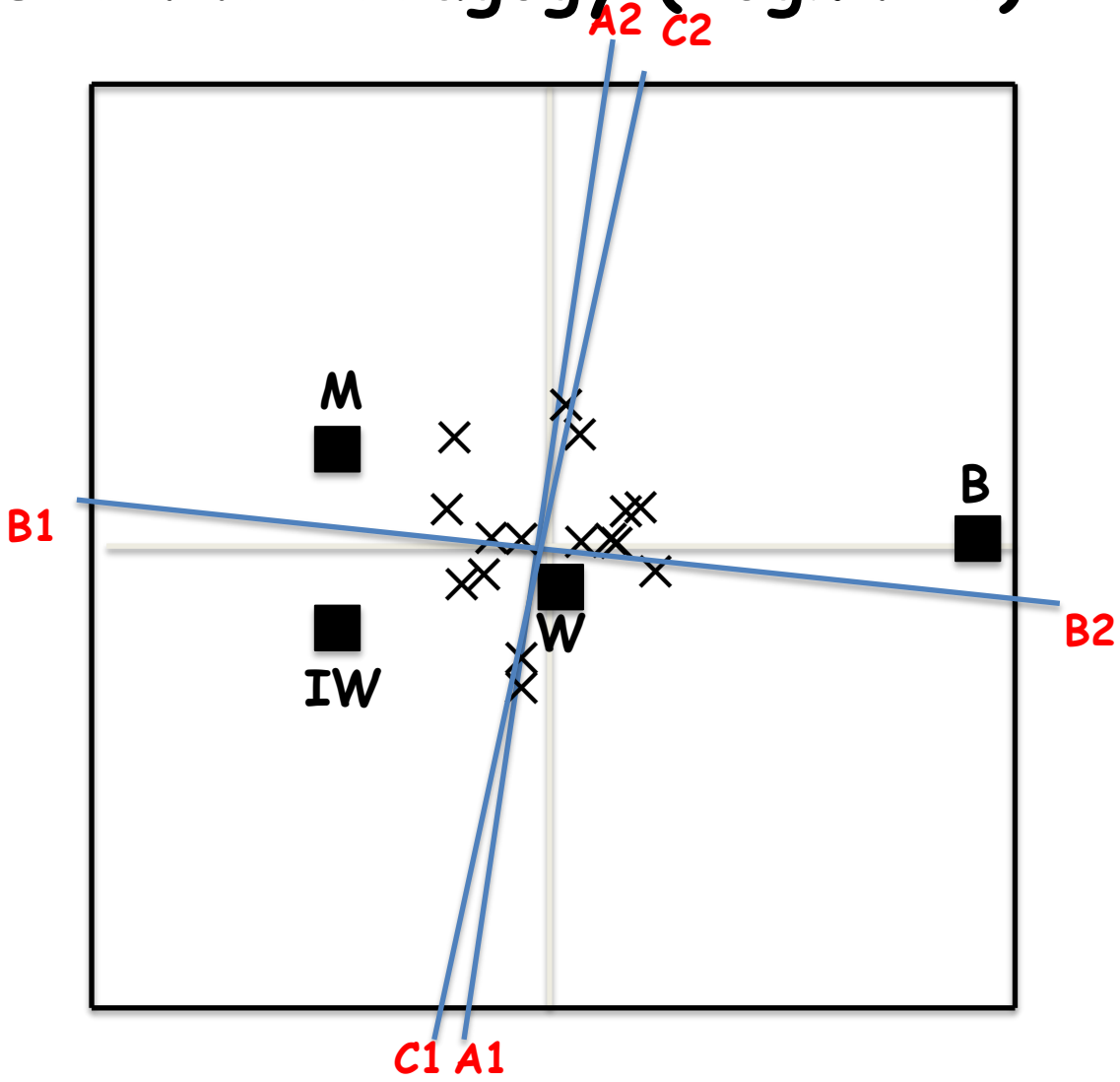
Models look realistic---Models are not represented properly

Principal Component Analysis: How I see the Pedagogy (Cognitive)



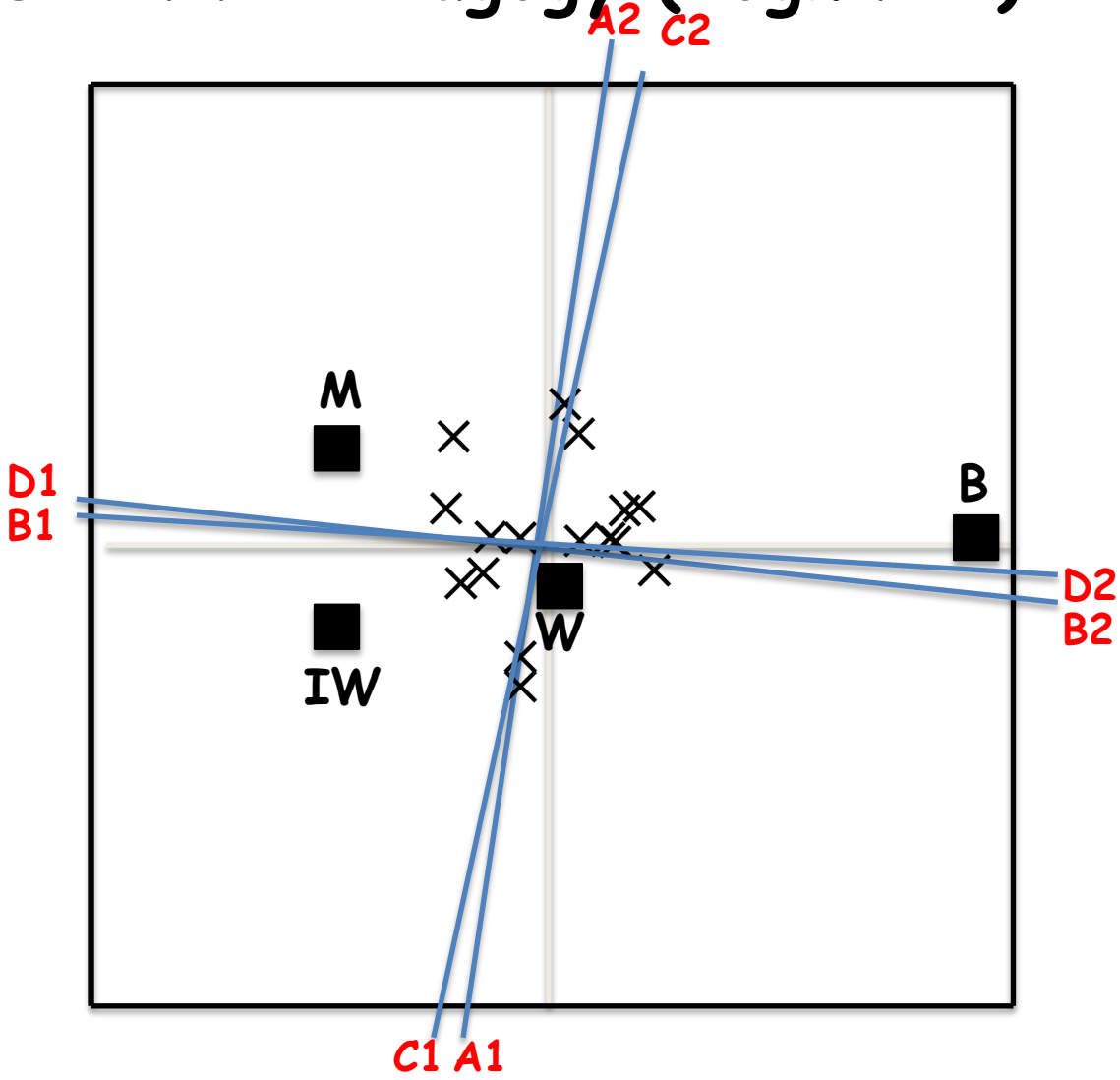
Gives a molecular visual aid---Can't picture what a molecule looks like

Principal Component Analysis: How I see the Pedagogy (Cognitive)



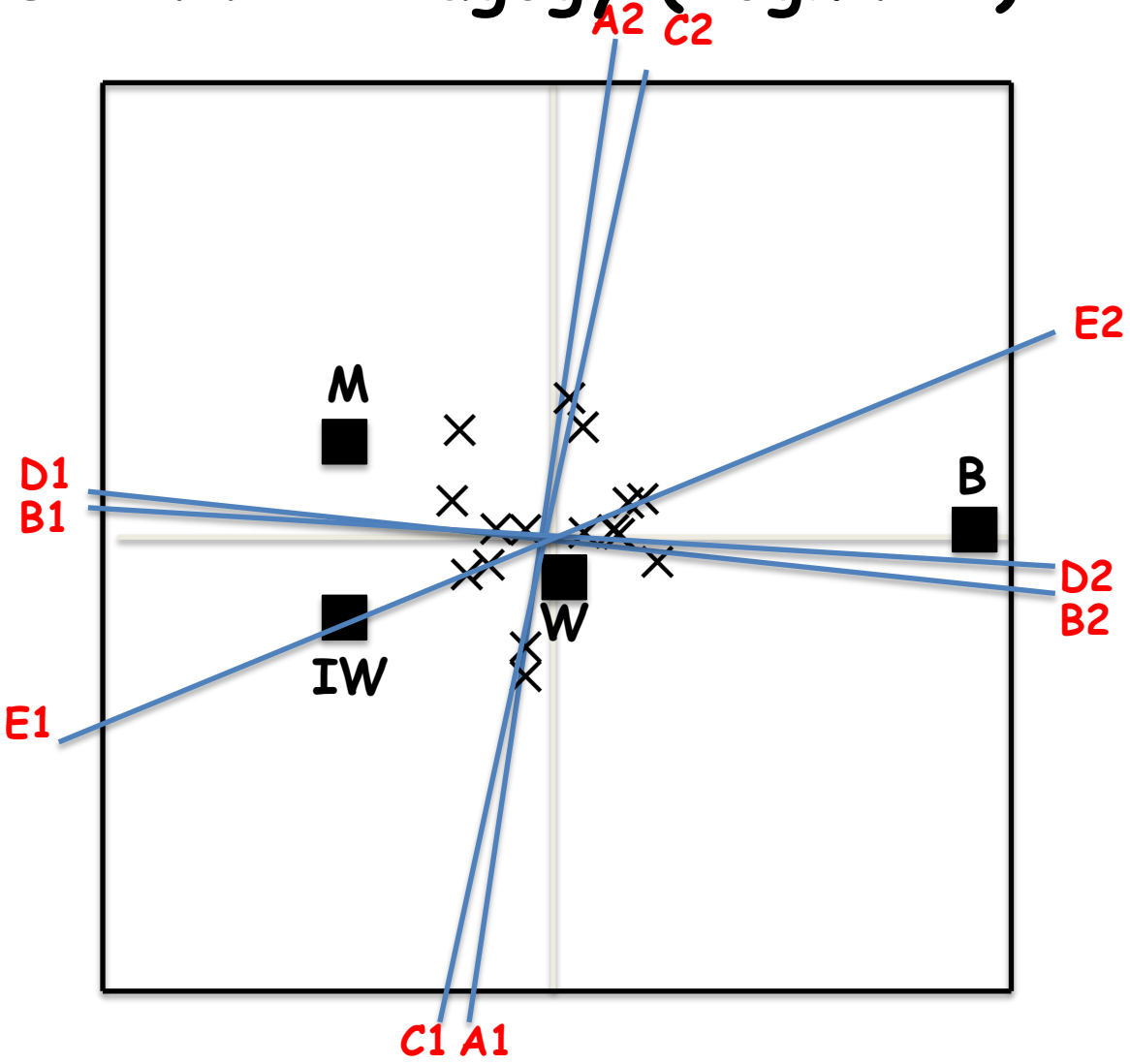
I can see how states of matter behave---I don't really know how states of matter behave

Principal Component Analysis: How I see the Pedagogy (Cognitive)



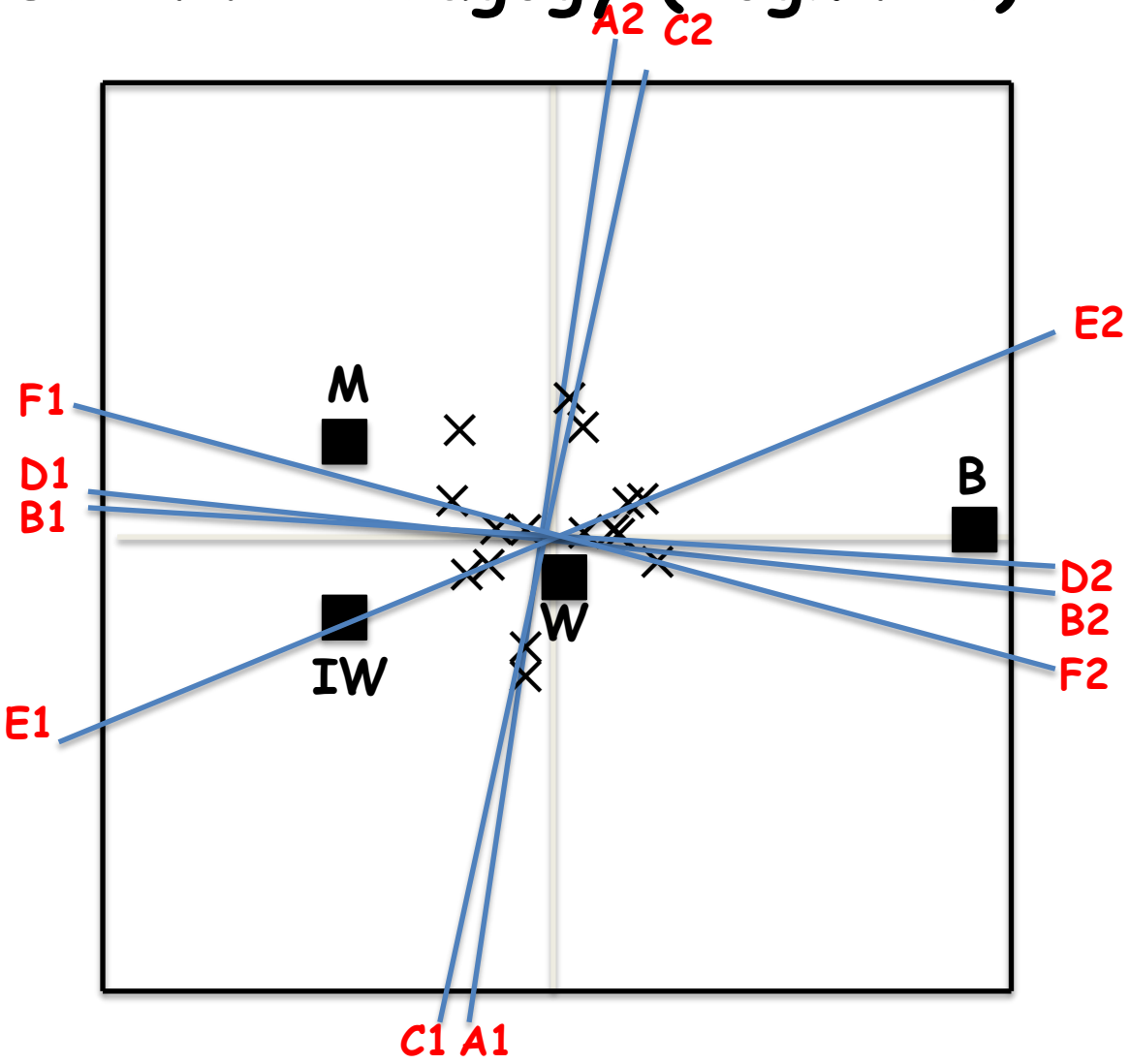
I see what others are thinking---I only have my own opinion

Principal Component Analysis: How I see the Pedagogy (Cognitive)



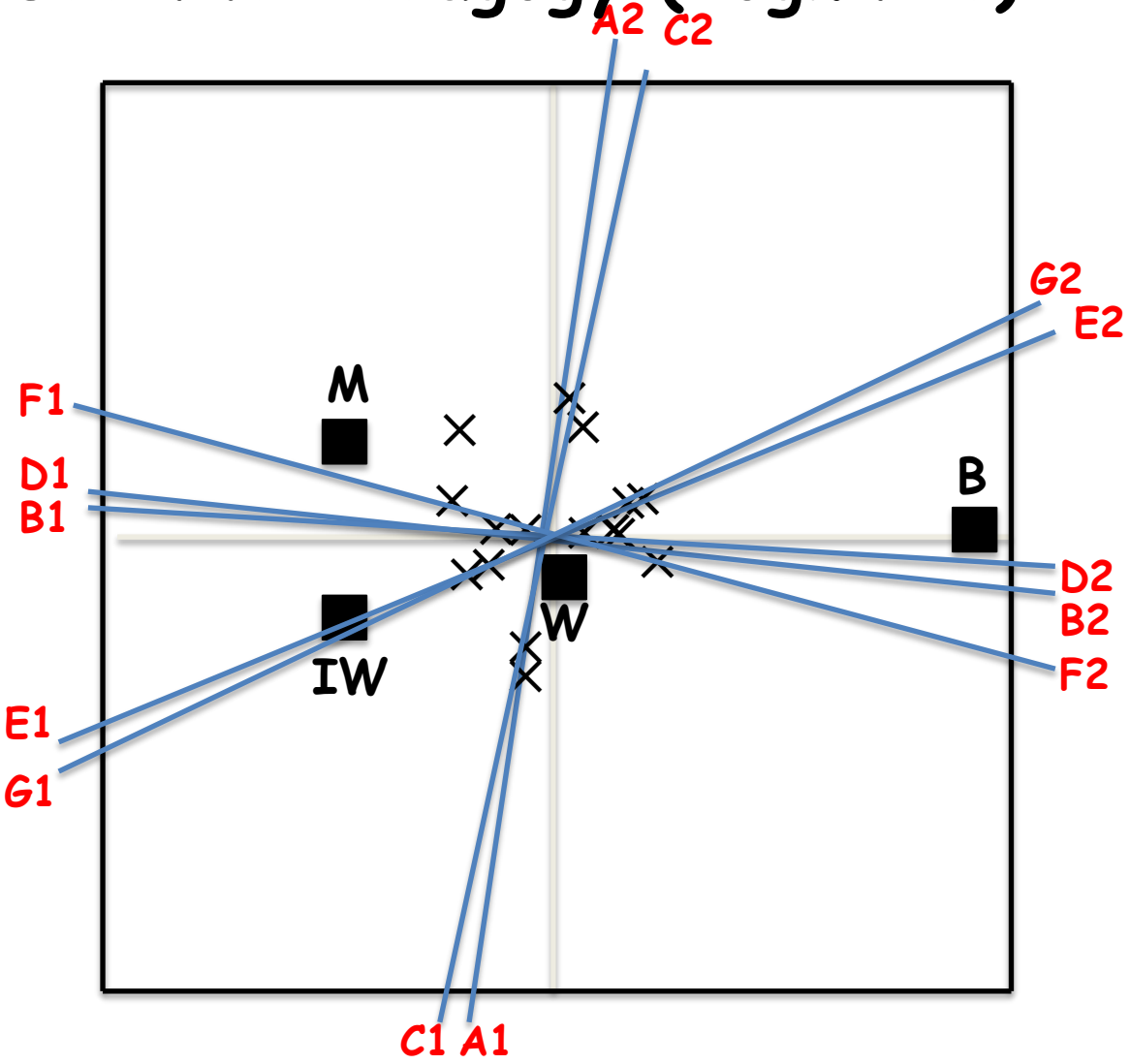
I get to make my own notes and drawings---Just given notes I might want to word differently

Principal Component Analysis: How I see the Pedagogy (Cognitive)



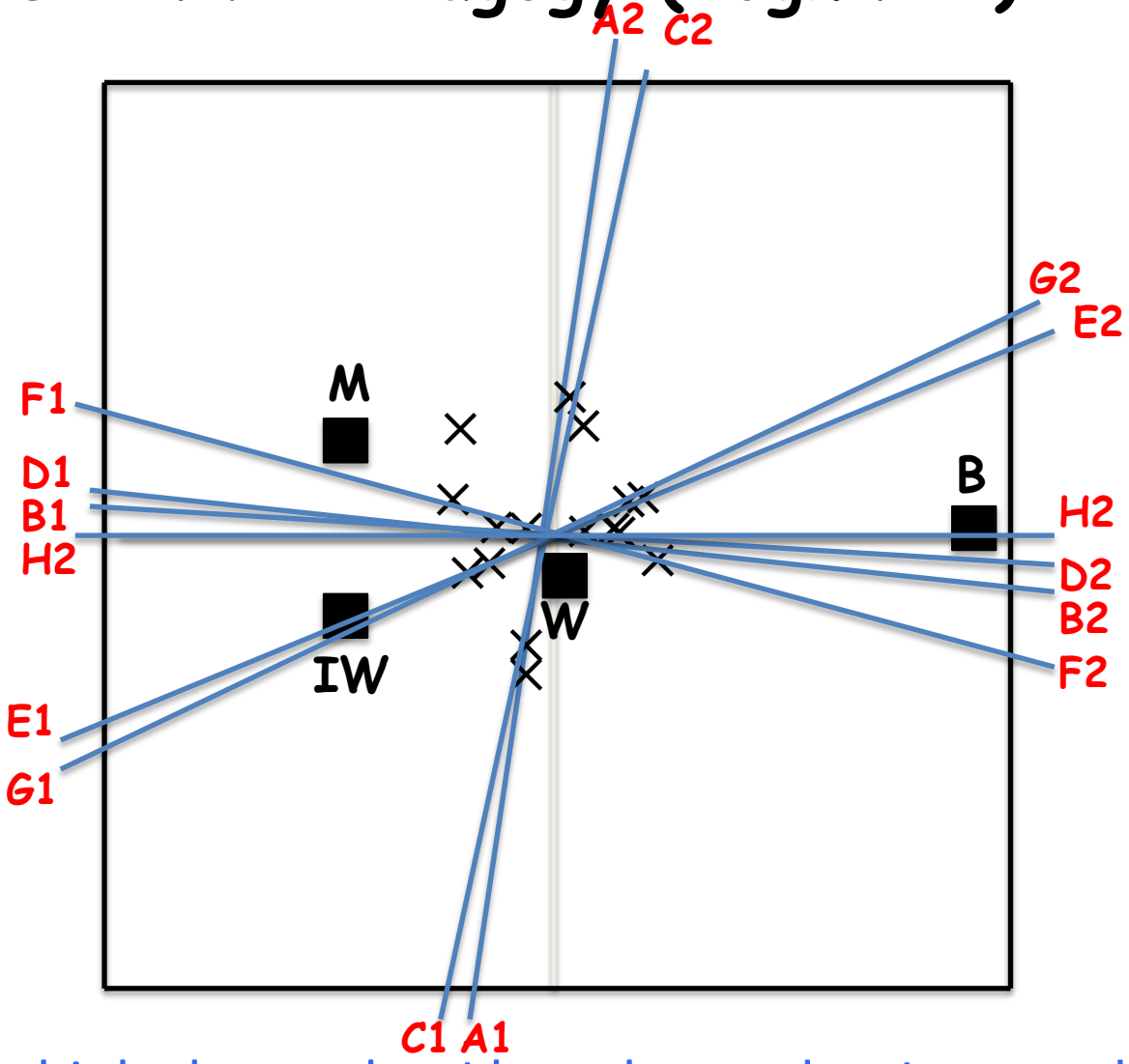
Allows me to express my own way of understanding---Just given the information and I have to give it back exactly

Principal Component Analysis: How I see the Pedagogy (Cognitive)



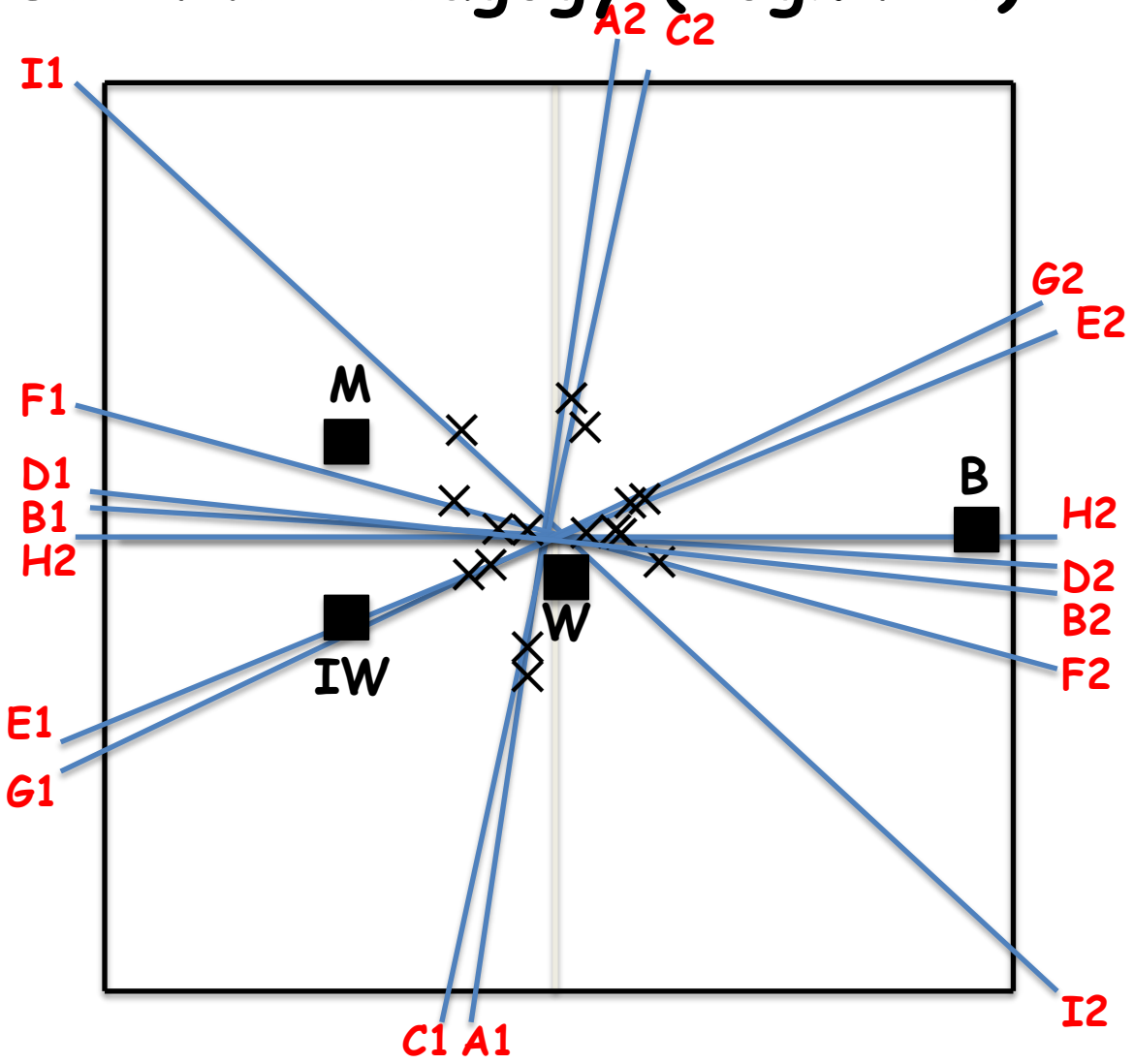
I actually get to figure things out for myself---Just look and read the information that is given

Principal Component Analysis: How I see the Pedagogy (Cognitive)



Allows me to think about what I have learned so I can understand and remember---Just read over someone else's thoughts

Principal Component Analysis: How I see the Pedagogy (Cognitive)



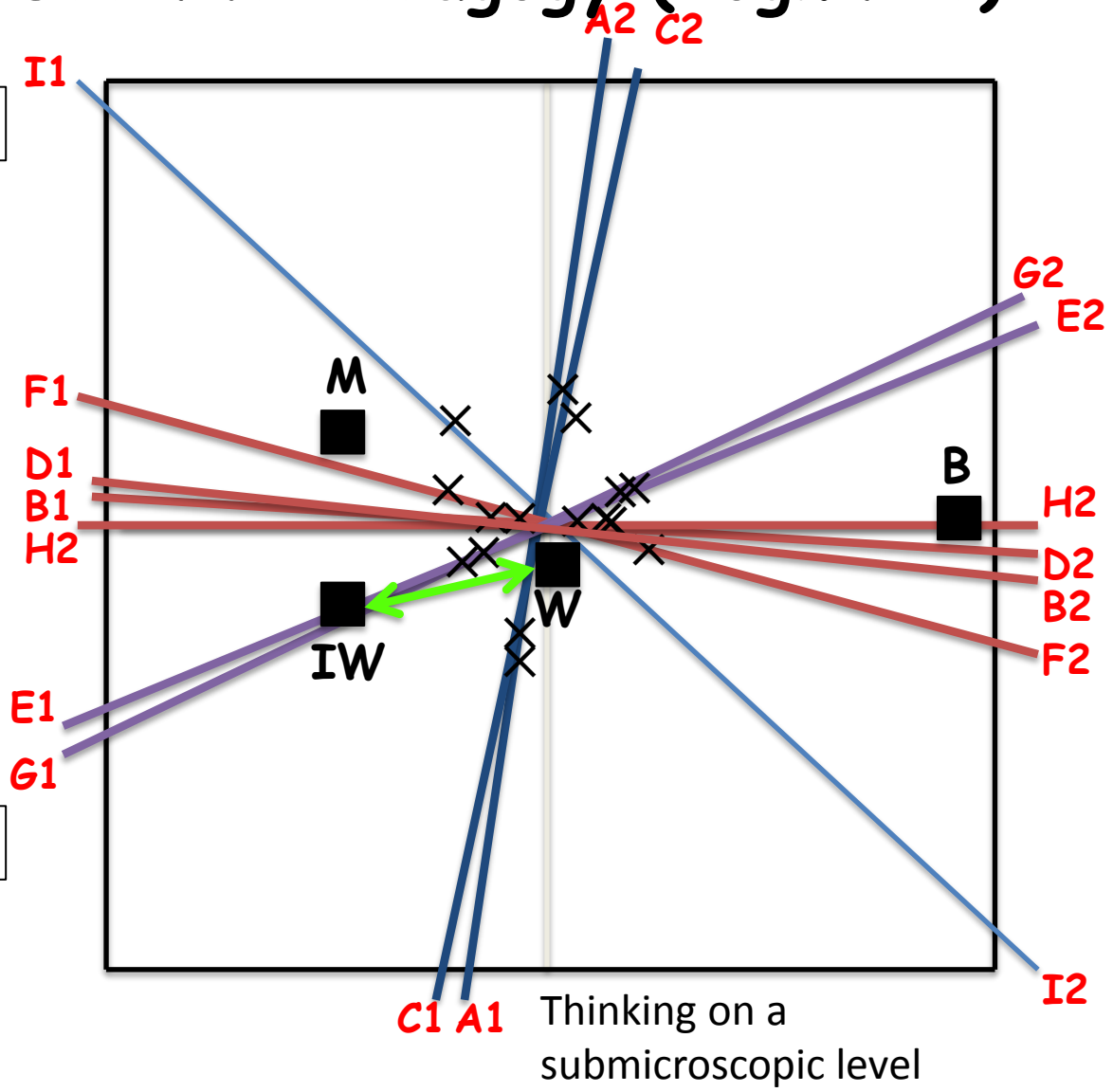
I understand better if I make or model something---Just learn off notes and pictures

Principal Component Analysis: How I see the Pedagogy (Cognitive)

Modelling

Thinking / Processing

Self- Reflection



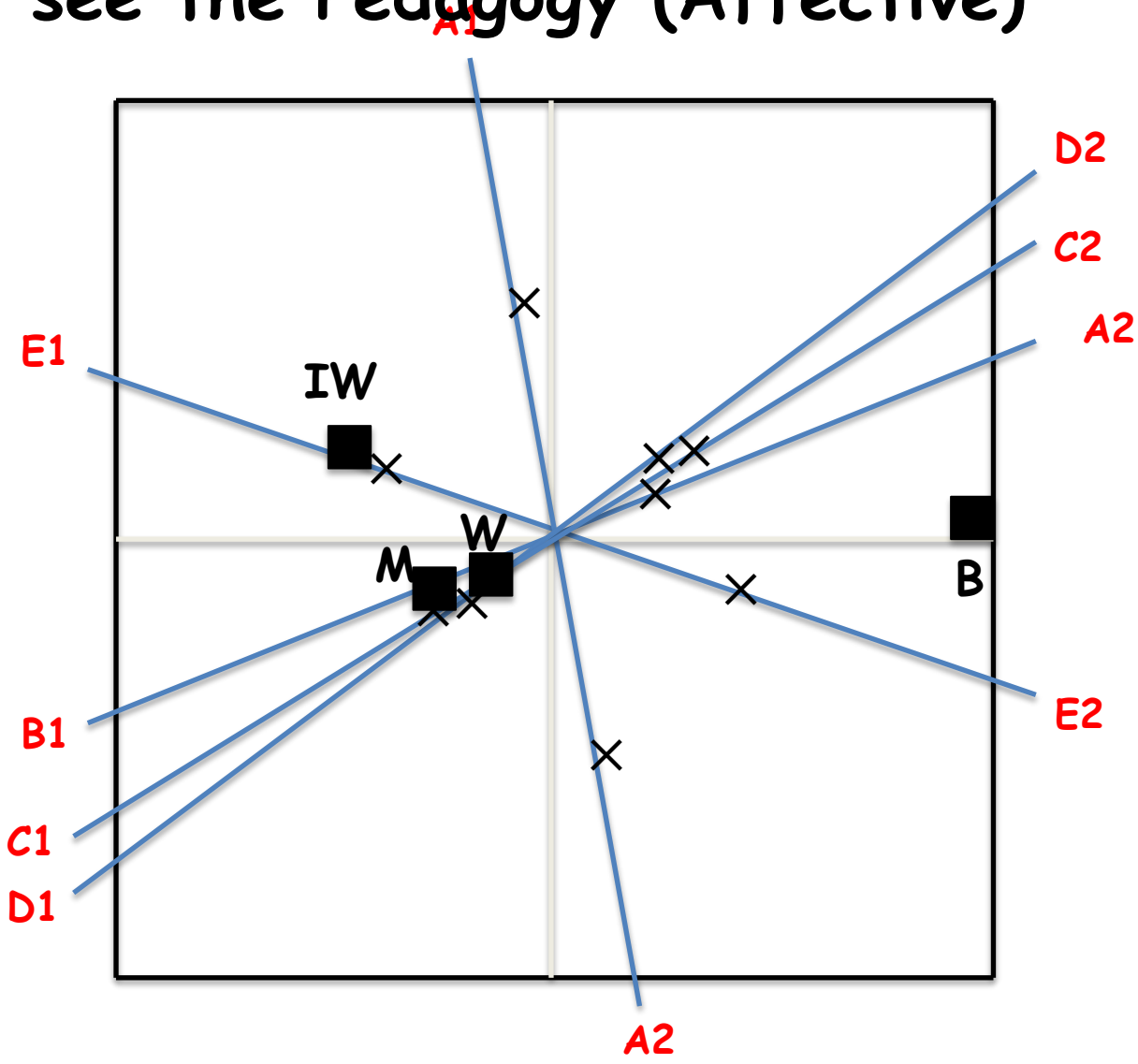
Thinking on a submicroscopic level

Variance: Component 1 (92.1%): Component 2 (5.8%) > 80%

Repertory Grid 2013 Pedagogy – Affective (n=20)

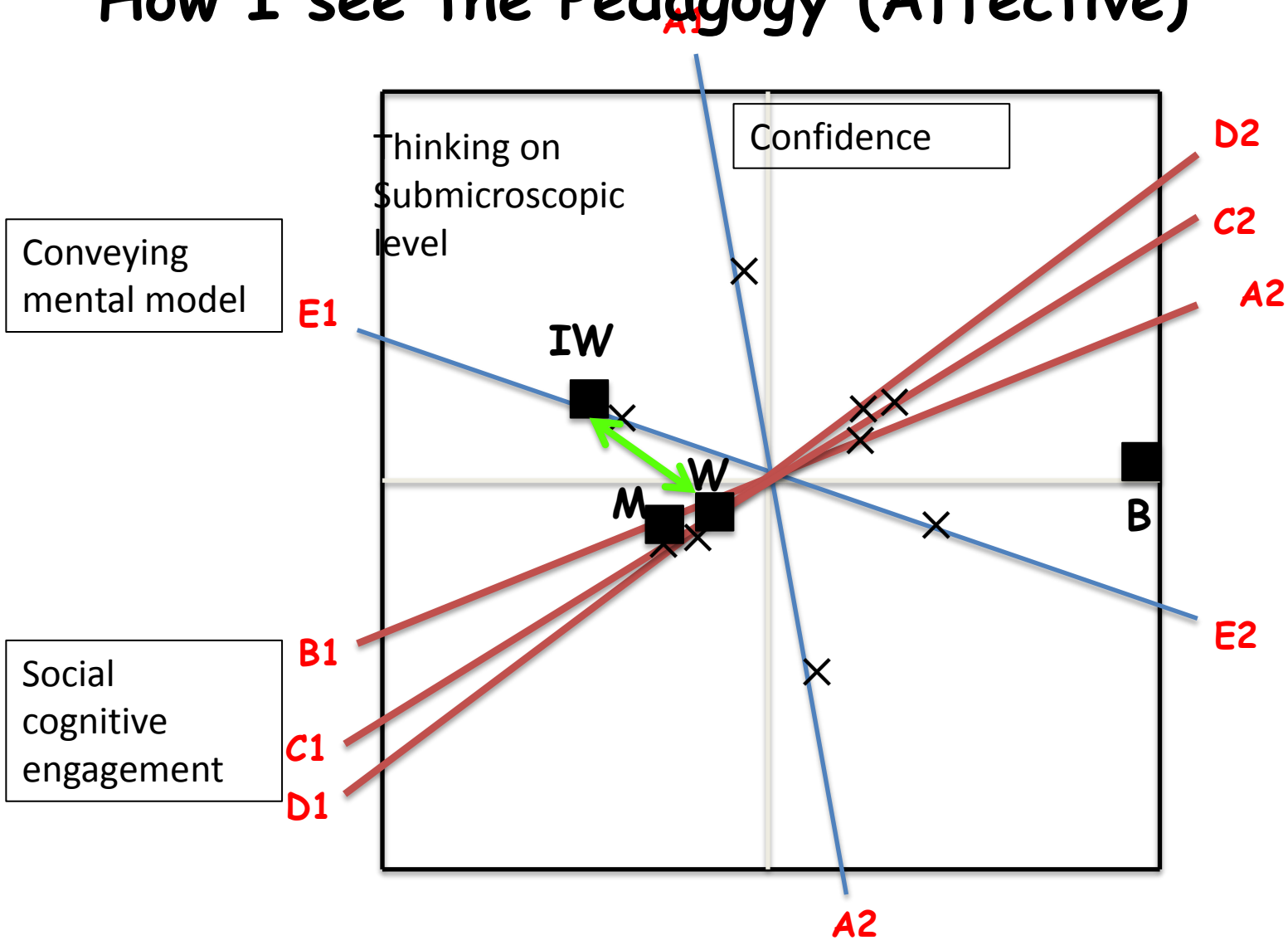
1Preferred Pole	Modelling	Textbook	Work Book	How I would like to see this workbook	Negative Pole 5
I feel more confident as i know what atoms can make up a molecule A1	2.2	2.2	2.0	1.6	I would not be sure if I understand how to make a molecule properly with the right atoms A2
I feel I get to help someone who is confused (during group-work) B1	2.4	3.1	2.3	2.3	I don't feel helpful B2
I know I understand and so I feel more confident C1	2.1	3.2	2.2	2.1	Feel pressure as I'm not sure when I work on something on my own if it is enough to solve the problem C2
I use my own information to learn and I know from the group that it's not wrong D1	2.1	3.2	2.2	2.1	It's like maths where there is only one way of getting the answer D2
Get the opportunity to say what I think E1	2.1	3.5	2.4	1.8	Just given notes that i might want to word differently E2

Principal Component Analysis: How I see the Pedagogy (Affective)



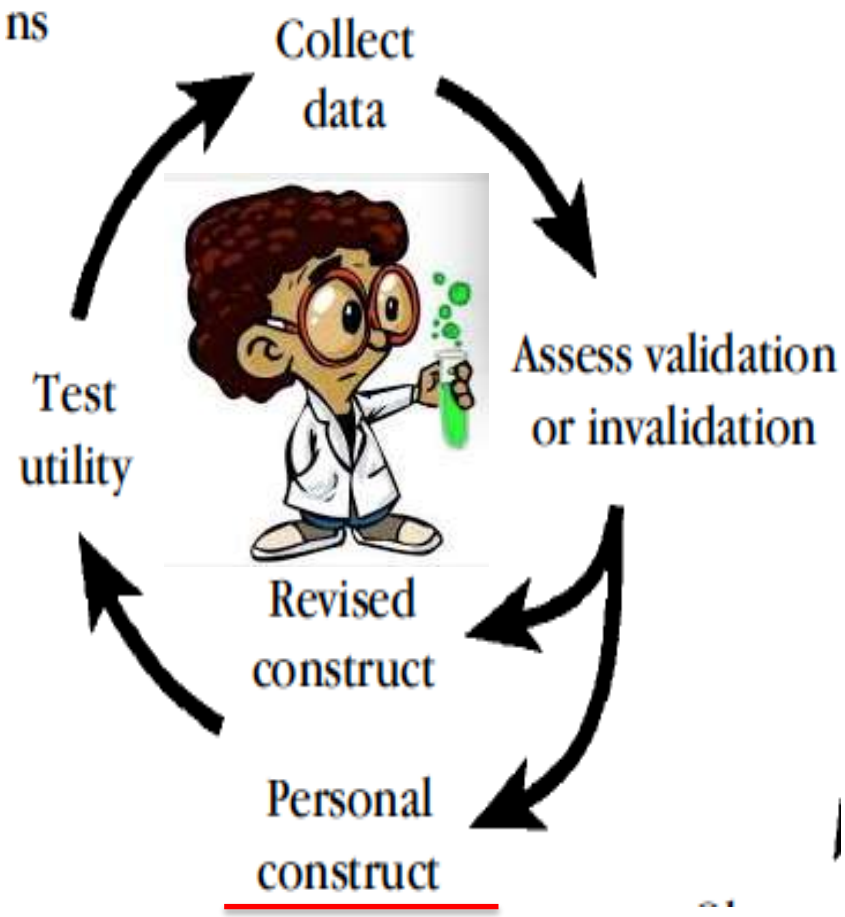
Variance: Component 1 (93.3%): Component 2 (5.2%) > 80%

Principal Component Analysis: How I see the Pedagogy (Affective)

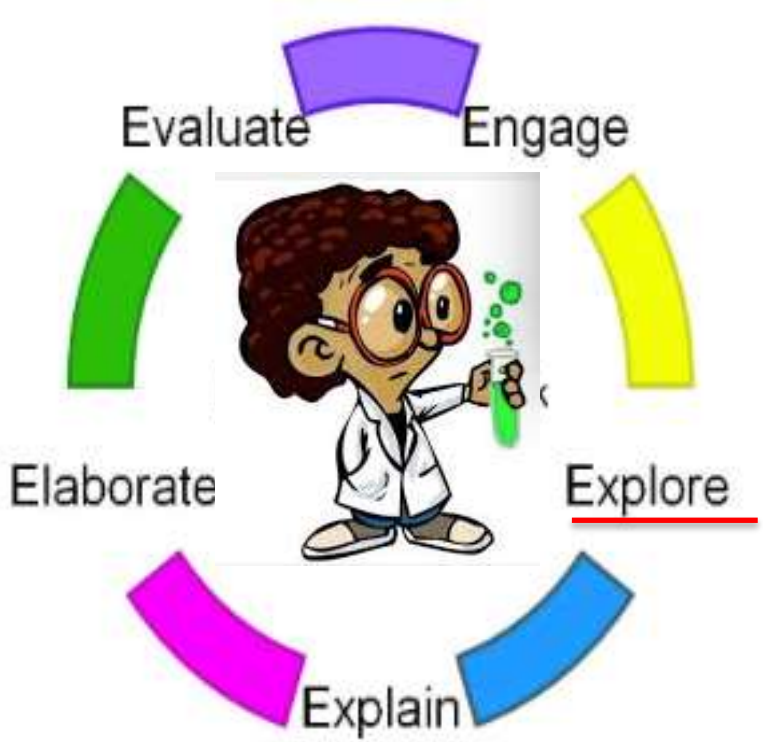


Variance: Component 1 (92.7%): Component 2 (5.7%) > 80%

Inquiry Based Learning through the Lens of A Personal Scientist

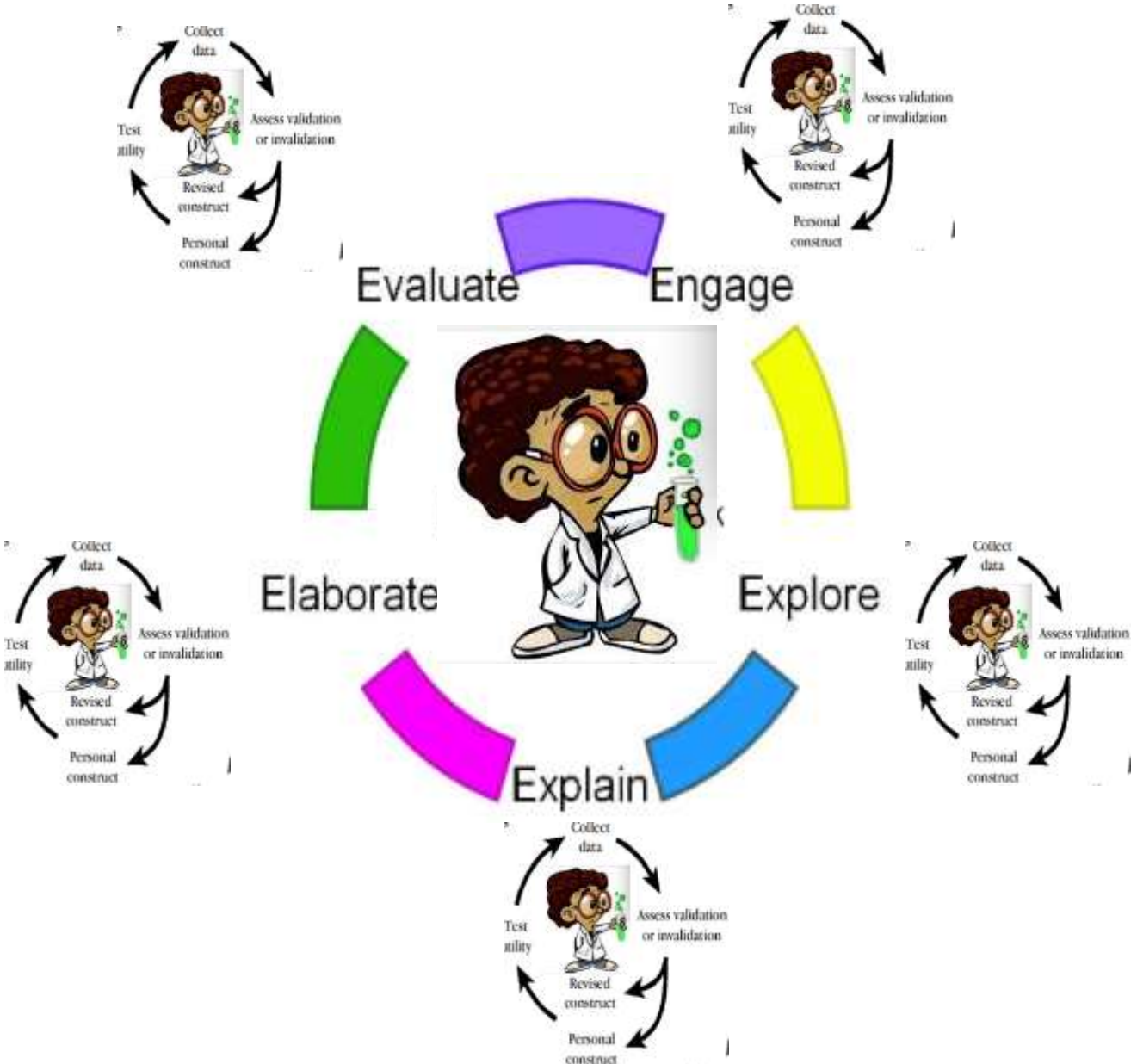


Kelly's Personal Scientist Model
Source: Kelly (1955 / 1991)

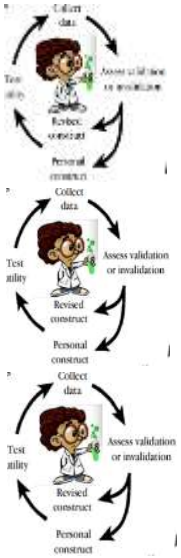


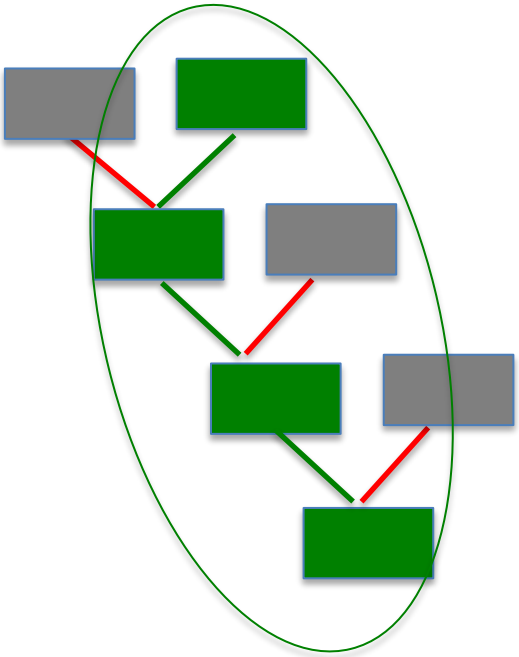
BCSE:

Inquiry Based Learning through the Lens of A Personal Scientist



Inquiry Based Learning through the Lens of A Personal Scientist





Super-ordinate Construct

Most sophisticated Sub-ordinate Construct

Intermediate Sub-ordinate Construct

Most Basic Sub-ordinate Construct

Full Dilation of Construct System → Creative Thinking → Transformative Education Via valid hierarchical construct path

Identifying Learning Gaps through the Lens of A Personal Scientist

1. A blown up balloon with 5g of air in it was brought into a room to help decorate it for Martina's birthday. The balloon burst and the air inside was released into the room. The room already had 1,650g of air in it – did anything happen to the mass of the air in the room. Explain if you think something did.

What _____

Reason _____

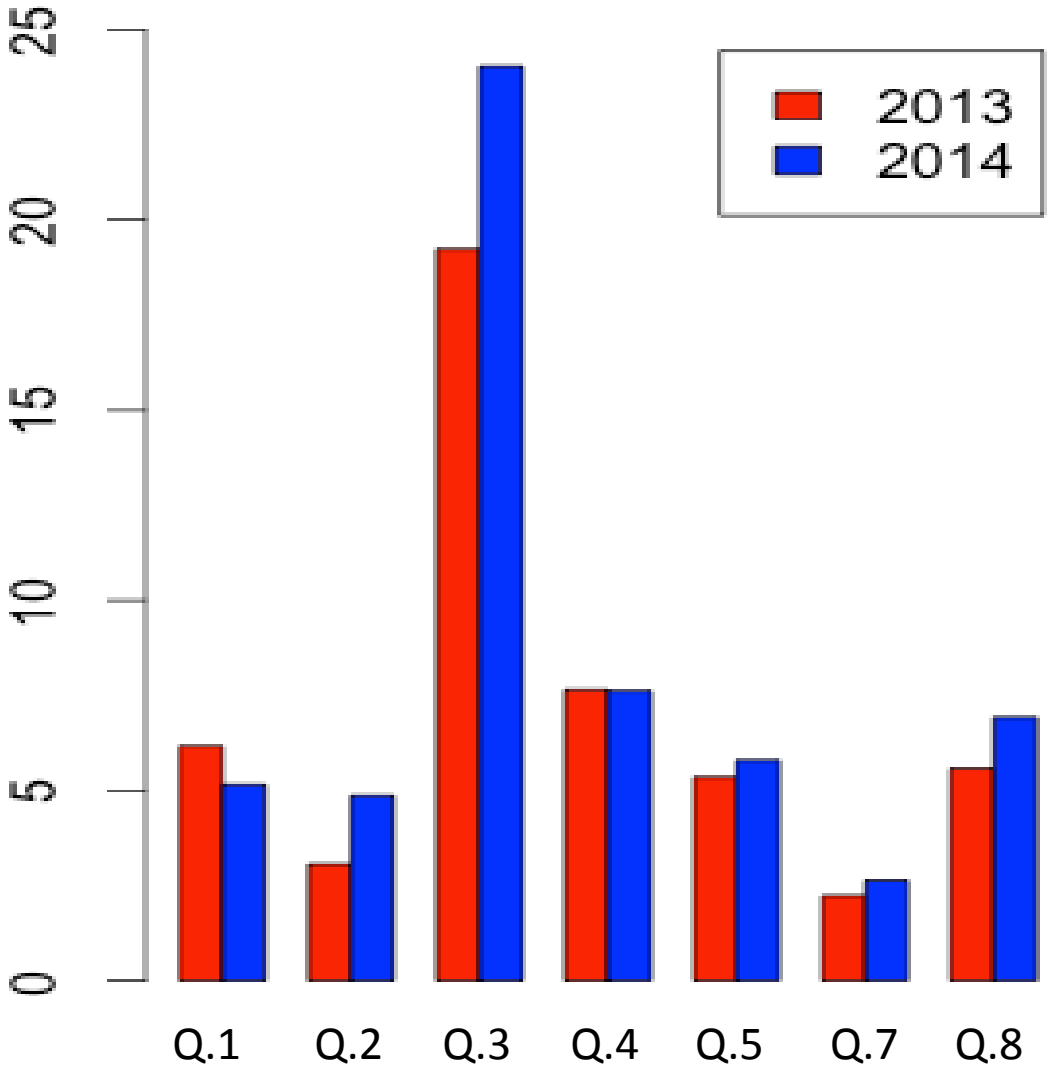
Identifying Learning Gaps through the Lens of A Personal Scientist

Superordinate Construct: Students were able to convey a specific quantitative understanding of the conservation of mass. They have displayed scientific protocol and detail within their answer.

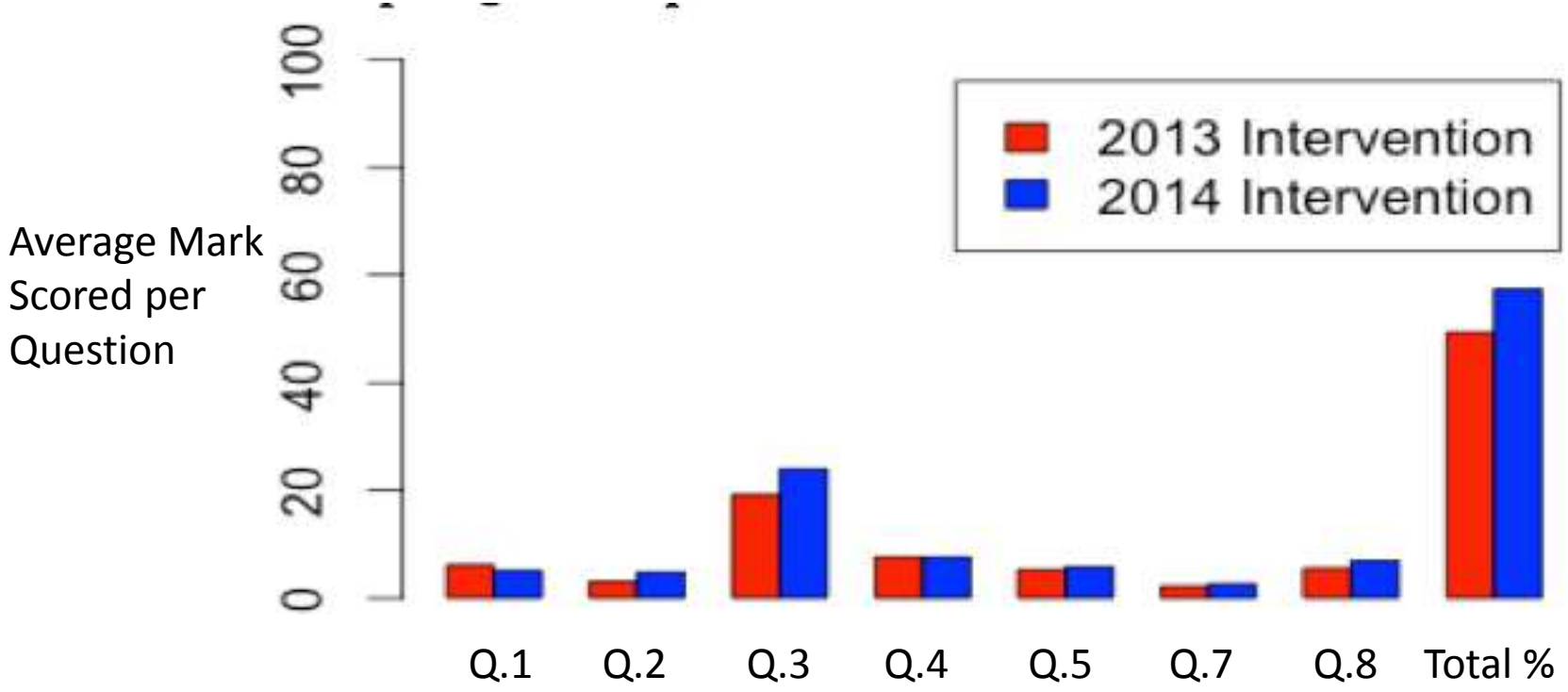
Sub-ordinate Constructs Preferred Pole		Negative Pole	Critical Differentiation Pole
Students were able to convey a specific quantitative understanding of the conservation of mass. They have displayed scientific protocol.	23.5%	Student has displayed a lack of acknowledgement of scientific protocol or detail within their answer.	Lack of scientific protocol
Student understands the additive nature of the process and can convey it qualitatively and quantitatively.	35.3%	Student understands the additive nature of the process but portrays a mainly fully qualitative understanding.	Full Quantitative
Student understands diffusion and gives partial qualitative and quantitative detail.	17.6%	Student appears to understand diffusion and gives partial qualitative detail but lacks any quantitative perception.	Partial Quantitative
Additive nature of process recognized because they have an understanding of the law of conservation of mass.	17.6%	Additive nature of process not recognized because they are likely to have a partial understanding of the law of conservation of mass.	Addition Operator
Partial understanding of the Law of Conservation of Mass	6.0%	No understanding of the Law of conservation of mass	No Understanding of Law of C of M

Formative Assessment Summary: Average Mark / Question (n = 17 in 2013; 40 in 2014)

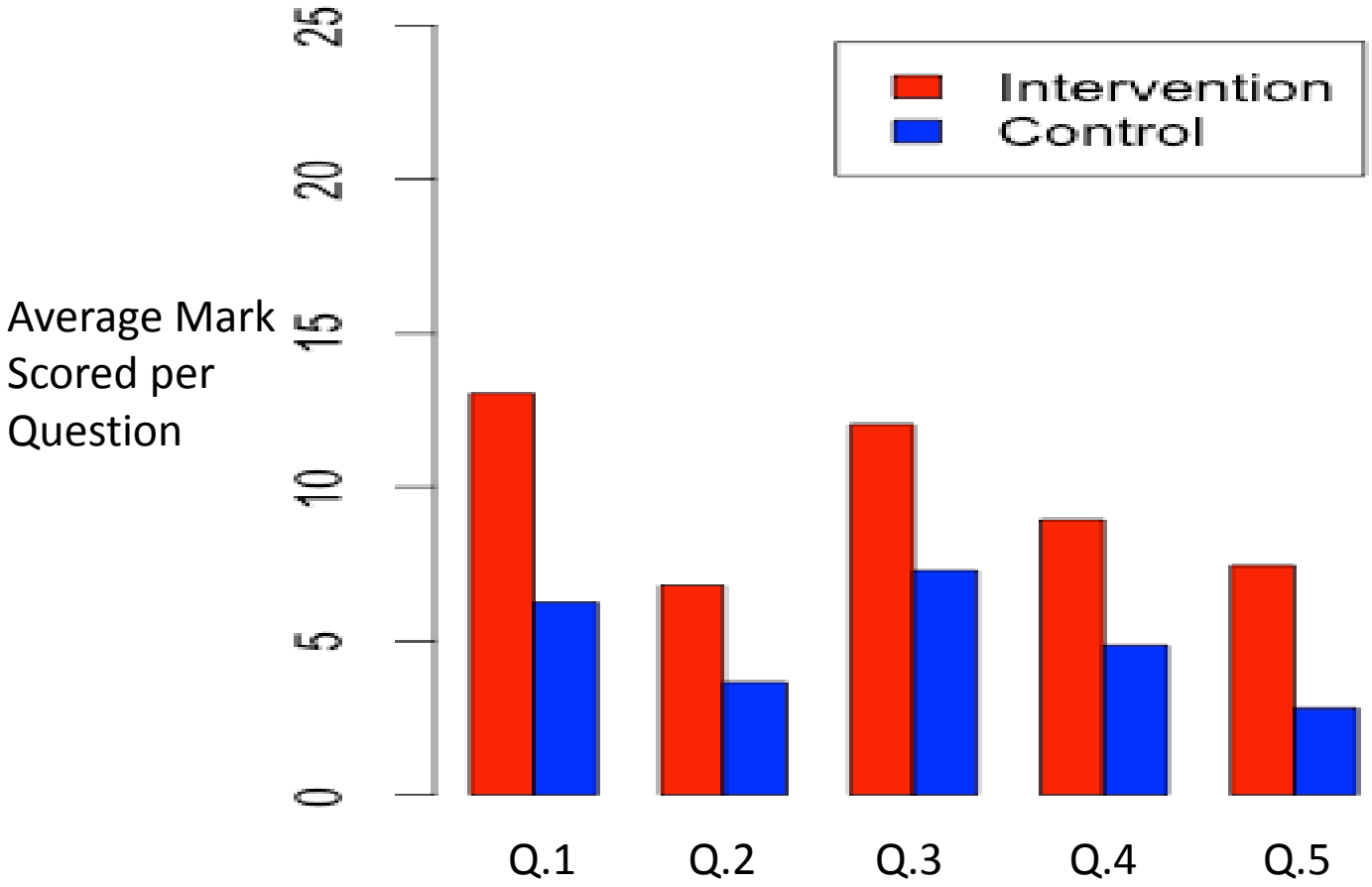
Average Mark Scored per Question



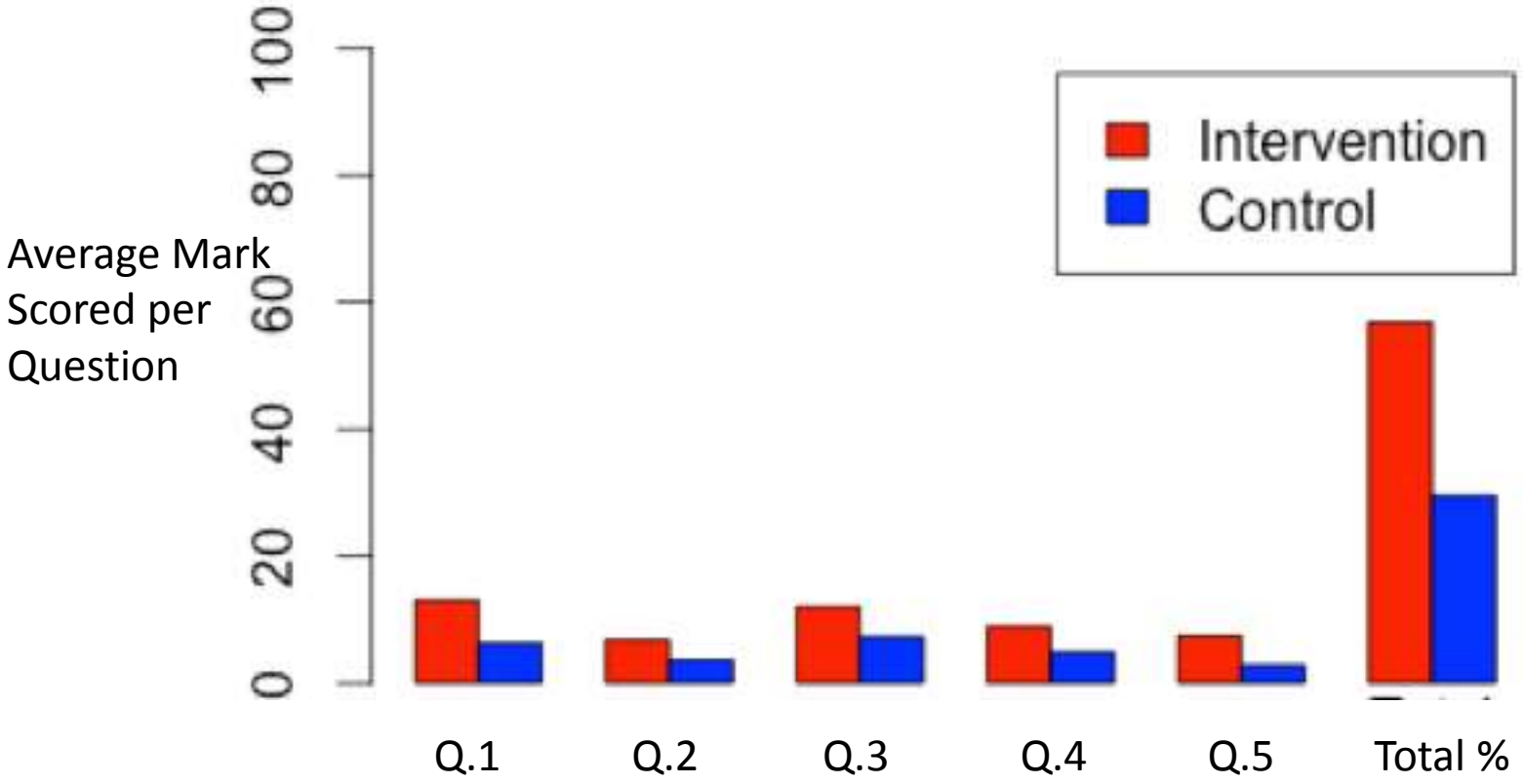
Formative Assessment Summary: Average Mark/Question to include Total % Achieved (n = 17 in 2013; 40 in 2014)



Summative Assessment Summary 2013: Average Mark/ Question
n =120 (Intervention = 20; Control = 100)

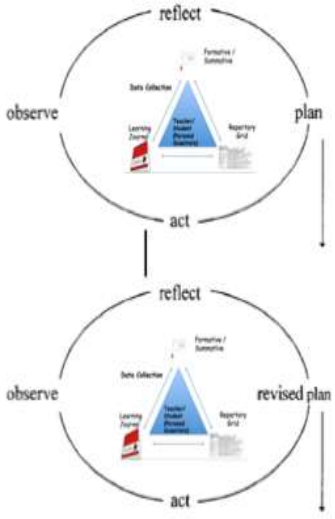


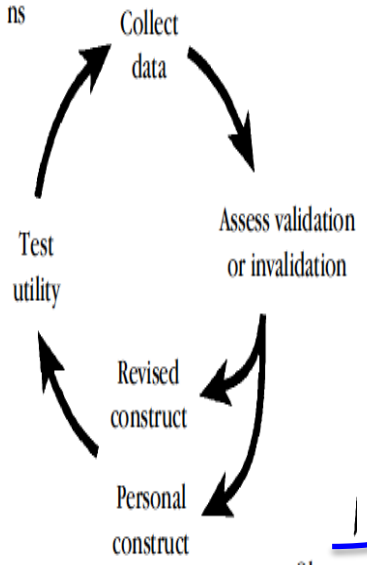
Summative Assessment Summary 2013: Average Mark/ Question to include Total % Achieved
n =120 (Intervention = 20; Control = 100)



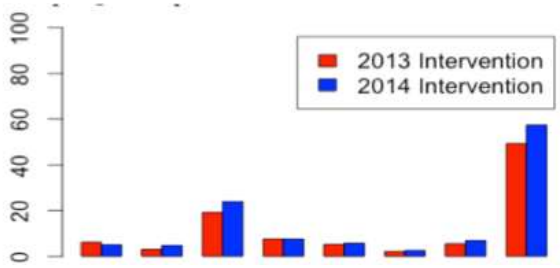
Conclusion

Method

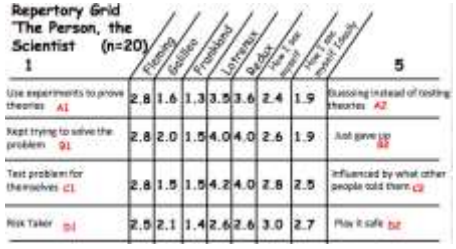




Evidence

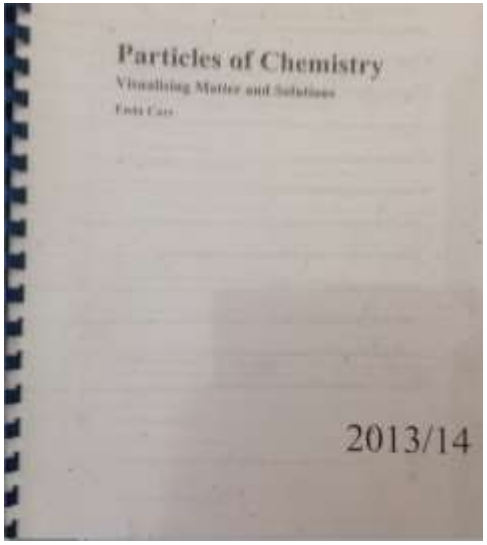


Quantitative



Qualitative

Result



- Cognitive Needs
  Affective Needs
- Learning gaps identified
- Transformative Education

Bibliography

IAP (2006) Report of the working group on international collaboration in the evaluation of inquiry-based science education (IBSE) programs. Santiago, Chile: Fundacion para Estudios Biomedicos Avanzados de la Facultad de Medicina [Online].

Fransella, F., Bell, R. & Bannister, D. (2004) A Manual for Repertory Grid Technique (2nd edition). Chichester: John Wiley & Sons

Jankowicz, D. (2004) *The Easy Guide to Repertory Grids* Chichester, UK: John Wiley & Sons.

Jones, L.J., Jordan, K.J. and Stillings, N.A. (2005) Molecular visualisation in chemistry education: the role of multidisciplinary collaboration. *Chemistry Education Research and Practice,* 6(3), pp. 136-149.

Kelly GA (1955) The Psychology of Personal Constructs, Vols 1 & 2. New York: WW Norton and Co. Inc. Republished (1991) London: Routledge.

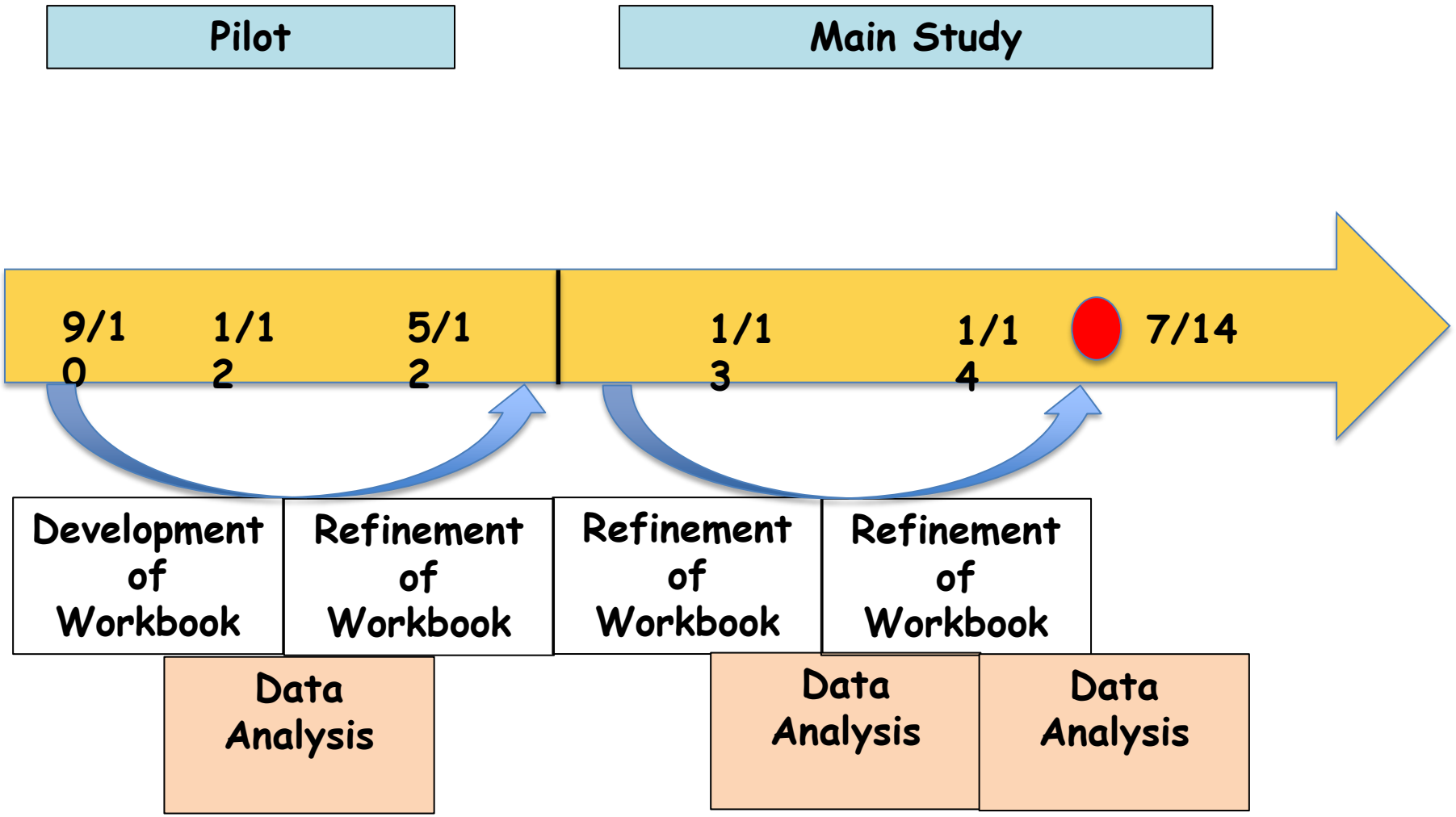
Kemmis S, McTaggart R (1982) The Action Research Planner. Victoria: Deacon University Press.

Mayer, R.E. and Moreno R. (2003). Nine ways to reduce cognitive load in mutlimedia learning, *Educational Psychologist* , *38*(1), pp. 43-52.

Pope and DeNicolo (2001) Transformative Education: Personal Construct Approaches to Practice and Research. London: Whurr Publishers

Waldrip, B., Prain, V., & Carolan, J. (2006) Learning Junior Secondary Science Through Multi-Modal Representation, Electronic Journal of Science Education 11 (1), 86-105.

Action-Research Context



Summative Assessment Type I

Formative / Summative Assessment Type II