Preparing the Ground: Considerations on Cultivating Scientific Inquiry through Curriculum

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Presentation Overview

- Purpose of Science Education
  - Contexts: IBSE, STS, Interdisciplinarity
- An issue of Engagement and Teacher Agency
  - The influence of Power Relationships in the Science Classroom
- The effects of Negotiating Curriculum with Students for Meaningful Learning
- Cultivating an Inquiry Habitus in Teacher Education
  - Developing Professional Capital and Agency
  - PCK and lesson study

Purposes of Science Education

- Economic: increasing STEM undergraduate numbers; Social: scientifically literate citizenry; Cultural: unique intellectual endeavour
- Diversity of purposes suggests the need for a flexible curriculum

"But the issues raised by student diversity and difference of aspiration and interest, have not gone away. Unless they are recognised and addressed, dissatisfaction with the science curriculum and its outcomes is likely to persist"

Millar (2014, p. 15)

Achieving these Purposes

- Inquiry Based Science Education
- Science Technology and Society
  - Context-based, connected to personal and societal issues (Aikenhead, 2005)
- Interdisciplinary approach
  - Real life problems require knowledge integration (Eurydice, 2011, p.64); Transdisciplinarity (Klein et al., 2012)
  - Challenging to implement for teachers but project- and problem-based learning may have some affordances (Chowdhary et al. (2014); Czerniak and Johnson (2014))

Models of IBSE

Student Decision-making & Responsibility

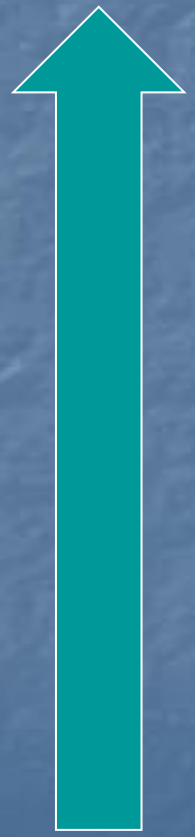


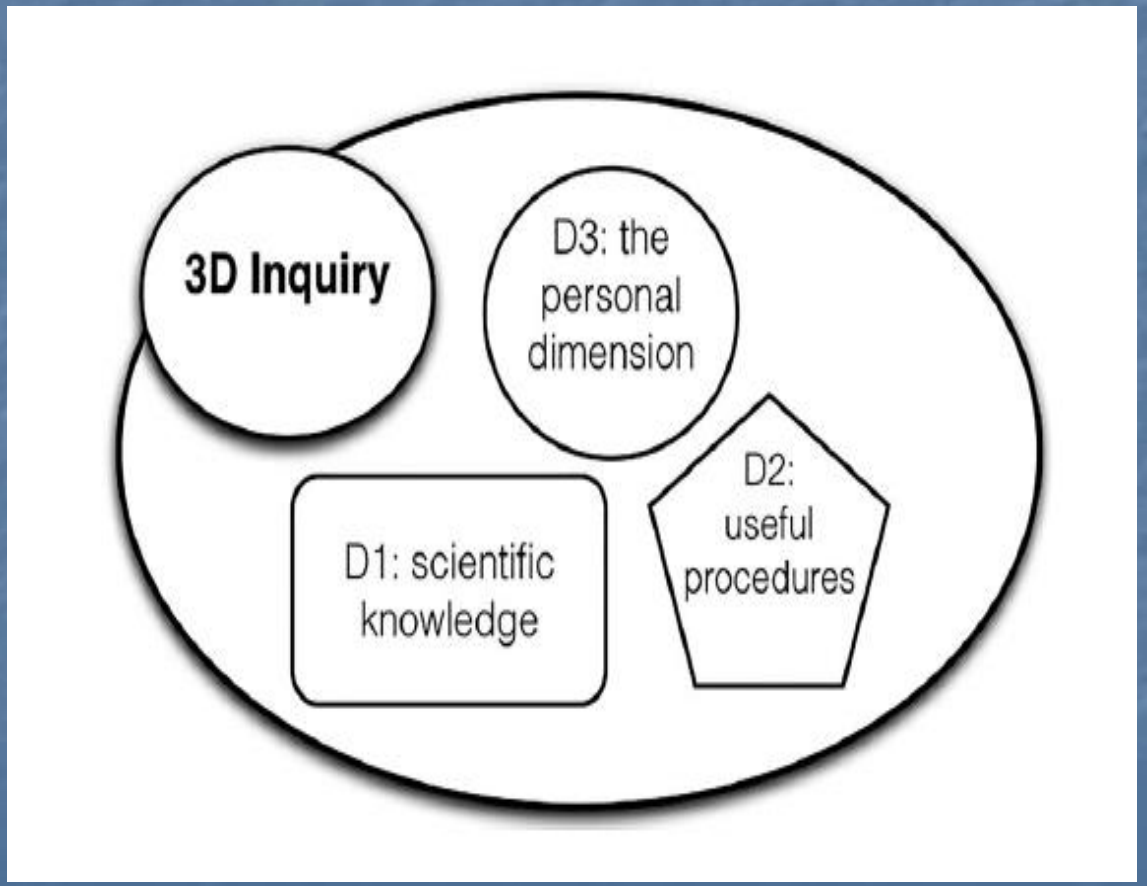
Table 1. Models of inquiry and associated skills.

Improved inquiry grid	Inquiry skill areas				
Level	1: Scientifically orientated questions	2: Priority to evidence	3: Explanations from evidence	4: Explanations connected to knowledge	5: Communicate and justify
3: Open inquiry	Learner poses a question	Learner determines what constitutes evidence and collects it	Learner formulates explanations after summarising evidence	Leaner independently examines other resources and forms the links to explanations	Learner forms a reasonable and logical argument to communicate explanations
2: Guided inquiry	Learner selects amongst questions, poses new questions	Learner directed to collect certain data	Learner guided in process of formulating explanations from evidence	Learner directed towards areas and sources of scientific knowledge	Learner coached in development of communication
1: Structured inquiry	Learner sharpens or clarifies question provided by others	Learner given data and asked to analyse	Learner given possible ways to use evidence to formulate explanation	Learner given possible connections to scientific knowledge	Learner provides broad guidelines to use to sharpen communication
0: Confirmation / verification exercises	Learner engages in question provide by others	Learner given data and told how to analyse it	Learner provided with evidence	Learner provided with precise connections	Learner given steps and procedures for communication

Bevins & Price (2016)

3D IBSE

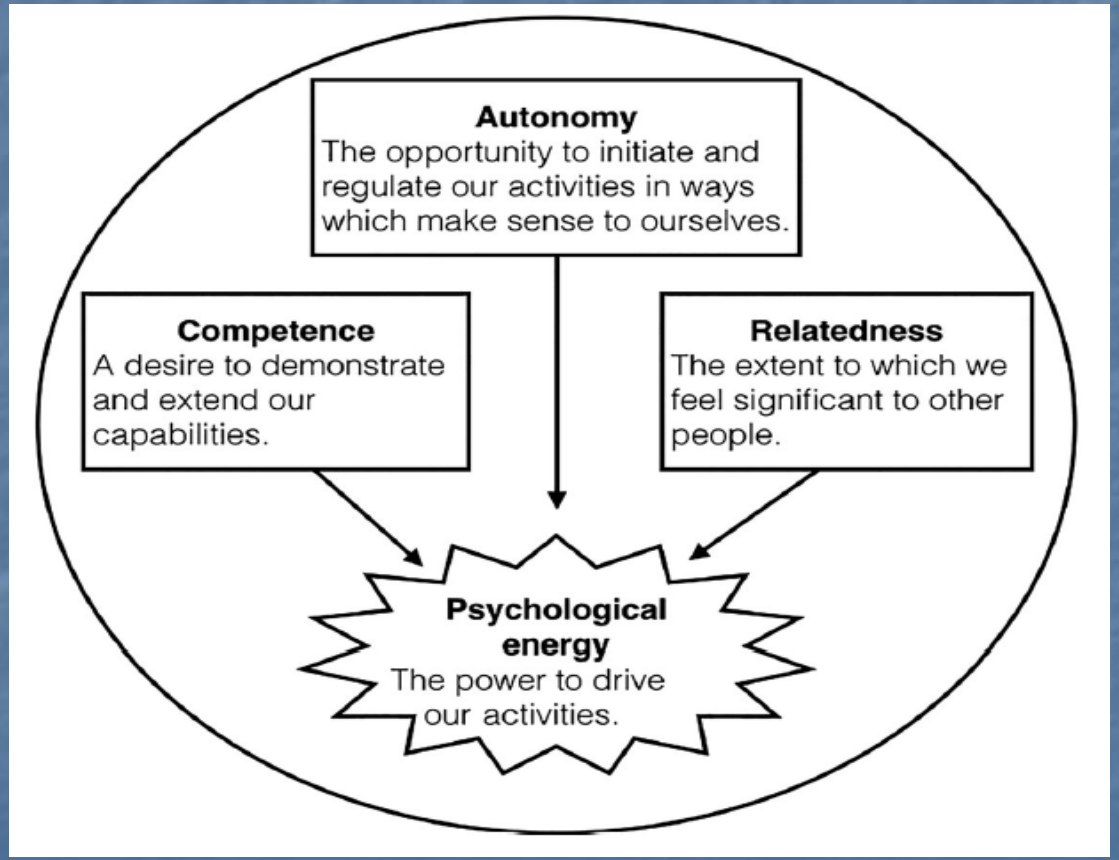
- Existing models reduce inquiry to a mechanistic sequence of tasks producing a distorted view of science (Windschitl et al., 2008)
- 3D model emphasises
  - Student agency, responsibility, decision- and sense-making
  - Intrinsic motivation



Bevins & Price (2016)

The Third Dimension of IBSE

"This model recognises the inquirer as an active agent who is required to navigate within, and manage the interactions between, these dimensions to construct a meaningful, productive inquiry that supports the construction of new knowledge, development of evidence handling skills and promotes student autonomy and exploration."



Bevins & Price (2016, p.25)

"Motivating" IBSE

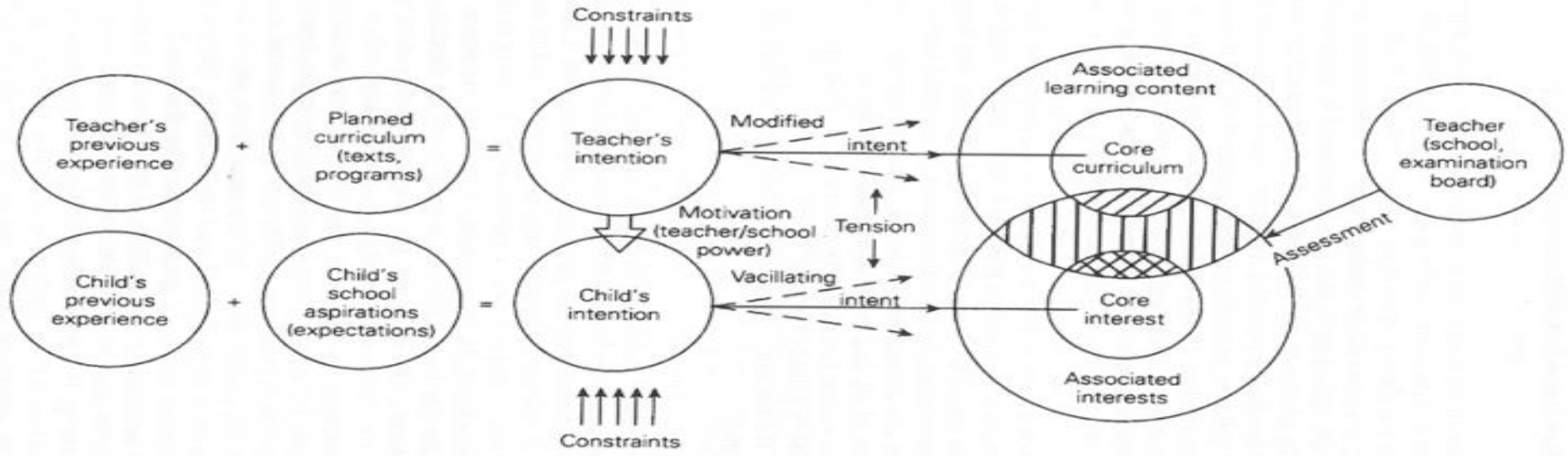


Figure 1: Model A: Motivation

Boomer et al. (1992)

Impact of the “motivated” curriculum

"One had to cram all this stuff into one's mind, whether one liked it or not. This coercion had such a deterring effect that, after I had passed the final examination, I found the consideration of any scientific problems distasteful to me for an entire year... It is in fact nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mainly in need of freedom; without this it goes to wrack and ruin without fail. It is a very grave mistake to think that the enjoyment of seeing and searching can be promoted by means of coercion and a sense of duty."

Attributed to Einstein, emphasis added

Difficulties in achieving IBSE

- Assessment (Formative & Summative)
- Ritualised Routines (Nuthall, 2005)
  - Difficulties in managing classes; cognitive economy ⇒ classroom game (of guess what's in the teachers' head) (Lemke, 2009)
- Teacher Schema (Korthagen, 2010)

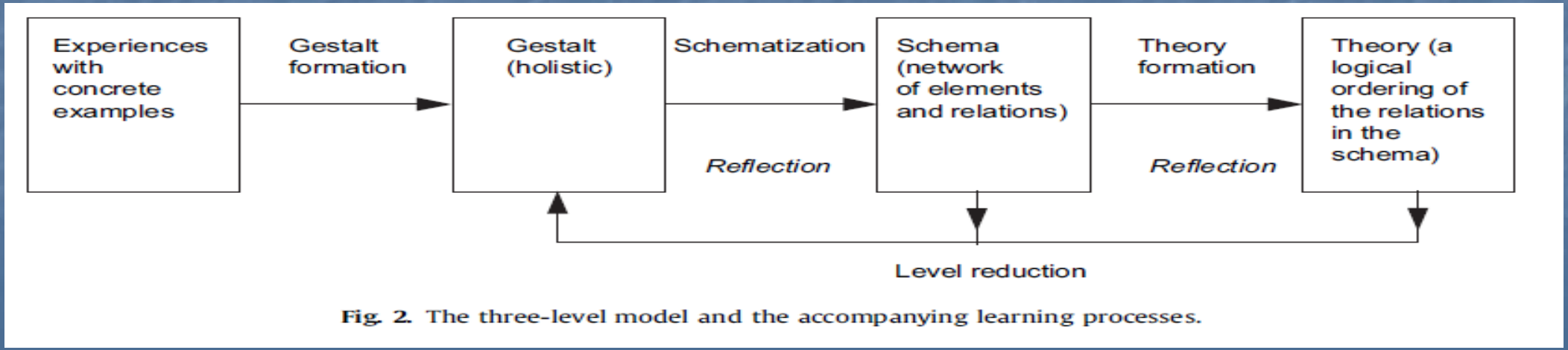


Fig. 2. The three-level model and the accompanying learning processes.

Power Relationships in IBSE

- "Didactic Contract" (Brousseau, 1998, cited in Donnelly et al., 2014) defines (implicit) expectations for student and teacher roles at odds with student ownership
- Power relationships are embedded in the Didactic Contract (Donnelly et al., 2014)
  - Characterised by compliance
  - Teachers believe student ownership is too challenging
  - "In an experiment, I don't like to be inventive. I follow instructions" (p. 2043)

Conceptualising power in the classroom

Table 1. Micro and macro conceptualisations of power

Author	Technique/ Characteristic	Description
Gore (1995)	Surveillance	Students are closely supervised and/or are expecting to be watched
	Regulation	Enforcing explicit rules to control through rewards, sanctions, and punishments
	Distribution	Organising students in space—separating, arranging, ranking, etc.
	Exclusion	Defining difference, setting boundaries or forming parameters
	Classification	Distinguishing individuals or groups from one another
	Individualisation	Aligning a characteristic to yourself or another person
	Totalisation	Aligning a characteristic to a collective group where you may or may not be a part of this collectiveness
	Normalisation	Defining norms by suggesting, demanding, setting, or conforming
Cornelius and Herrenkohl (2004)	Partisanship	Describes how power develops between students during their interactions with particular concepts and with each other, e.g. a student taking sides of an argument not based on the material, but based on a pre-existing relationship
	Persuasive discourses	Describes the intricacies of communication that can affect the power relations between people, e.g. a teacher speaking in an authoritative tone may not be accepted by peers, but would be accepted by students
	Ownership of ideas	Refers to how students' perception of who owns an idea, e.g. their teacher, their textbook, their peers, will affect their relationship with that idea and as a result, their willingness to engage with that idea

Donnelly et al. (2014)

Listening to students

Even in the 21st century in schools pupils sit in rows like the Victorians. You can only talk to the person next to you (this is probably why the teachers make us sit in rows) this means that in discussion work which is extremely important in today's society ideas and suggestions don't come as quickly.

Joanna, 13

I don't think I would get on very well in my ideal school because I am too used to being told what to do.

Frances, 15

In my ideal school…we will no longer be treated like herds of an identical animal waiting to be civilised before we are let loose on the world. It will be recognised that it is our world too.

Miriam, 15

Burke and Grosvenor (2005, pp.2, 7)

Engagement to ignite Motivation

- "To repeat the point made earlier, the change involved is not from teaching science to teaching 'about science'; it is about the 'driver' (Fensham, 2002) that is used to select the curriculum content." (Millar, 2014, p.18)
- Student engagement as the "driver" (Lawson and Lawson, 2013)
  - Engagement is malleable, a direct pathway to learning and is distinct from motivation
  - Current engagement characterised as "compliant", passive and needing to be stimulated by the teacher

Agentic Engagement

"…is manifest when students actively express their thoughts, opinions, and interests during activity (Ainley, 2012; Assor, 2012; Brooks et al., 2012; Hipkins, 2002); when they direct their own learning (Cleary & Zimmerman, 2012; Reeve, 2012); when they engage communally, collectively, and critically with others (Davis & McPartland, 2012; Mahatmya, Lohman, Matjasko, & Farb, 2012; O'Conner, Hanny, & Lewis, 2011; Polman & Miller, 2010); and when they use culturally relevant tools and technologies (Dockter et al., 2010; Mitra & Serriere, 2012)."

Lawson and Lawson (2013, p.447)

Agentic Engagement

- Cultural congruence: changes in classroom routines supporting student identity
- Cultural relevance: emotions and cognitions students experience when learning has personal significance and practical relevance
- Cultural correspondence: connecting learning with prior knowledge and experience

Lawson and Lawson (2013)

Teacher Agency for Student Engagement

- "There is an emerging tendency in curriculum policy in the UK and elsewhere to acknowledge the importance of teachers' agency – that is their active contribution to shaping their work and its conditions – for the overall quality of education"
- Significantly influenced by Teacher Beliefs

Biesta et al. (2015, p.624)

Beliefs and Agency

- Students
  - Good relationships; Deficit mentality & ability is fixed: *"No, they do not actually understand what responsibility for their own learning is. And they are not capable of managing it."*
  - *"Thus, students with 'poor' ability, or students who do not take 'responsibility' for their own learning provide a justification for the teacher to abdicate some professional responsibility, blaming students as 'mad, bad or stupid' (Watzlawick, Wickland & Fisch, in Salomon, 1992, p. 45)".*
- Role
  - Belief in facilitation but sceptical about pedagogical changes
  - Anxious about change (required autonomy) and deference to authority

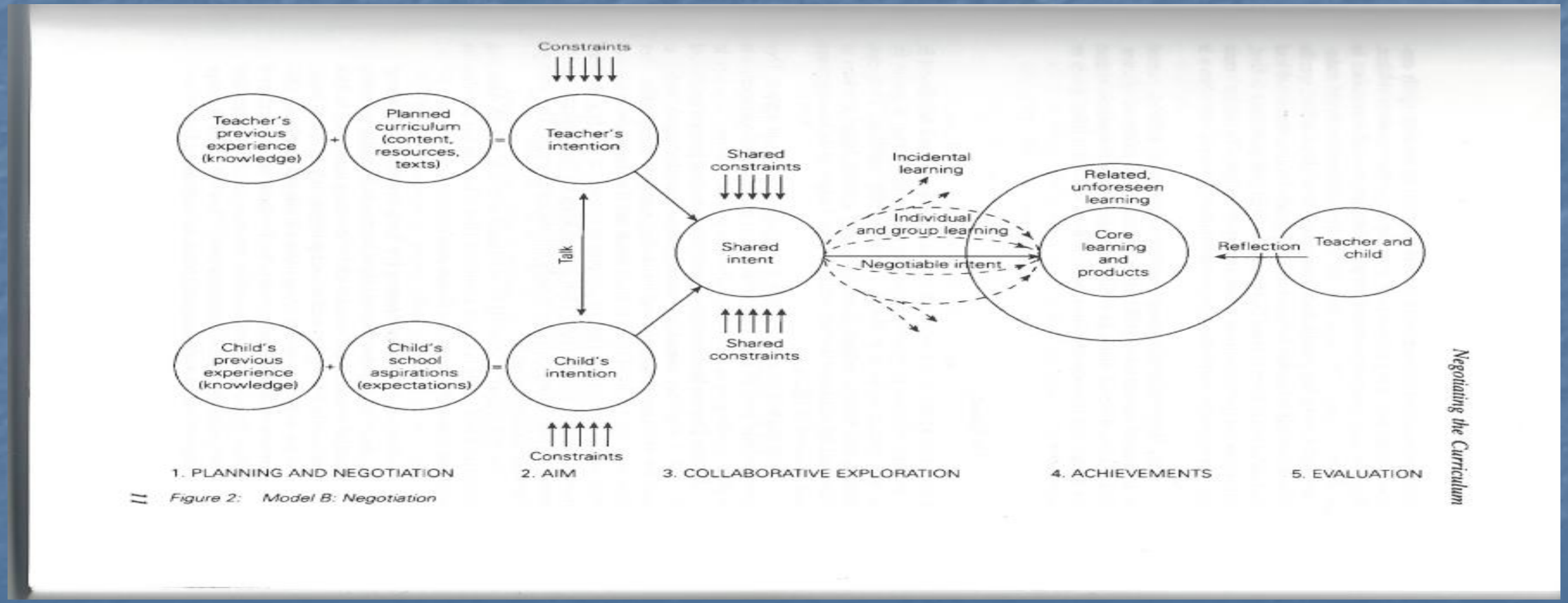
Biesta et al. (2015, p.631)

Beliefs and Purpose

- *"Many of the discourses of modern schooling appear to be a mishmash of competing and vague ideas – personalisation, choice, learning, subjects, etc. – and, in the absence of opportunities for systematic sense-making in schools, teachers are regularly left confused about their role. Arguably, much of the blame for this situation lies in externally imposed systems which alter the dynamics of schooling, leading to incremental change without the development of a clear philosophy of education to underpin the changes in question, and a professional collegiality that enables its development."*
- *"Perhaps the most important finding in the particular case we have presented here, is the absence of a robust professional discourse about teaching and education more generally….As a result the existing beliefs cannot be experienced as choices but appear as inevitable."*

Biesta et al. (2015, pp.636-637)

Negotiating Curriculum



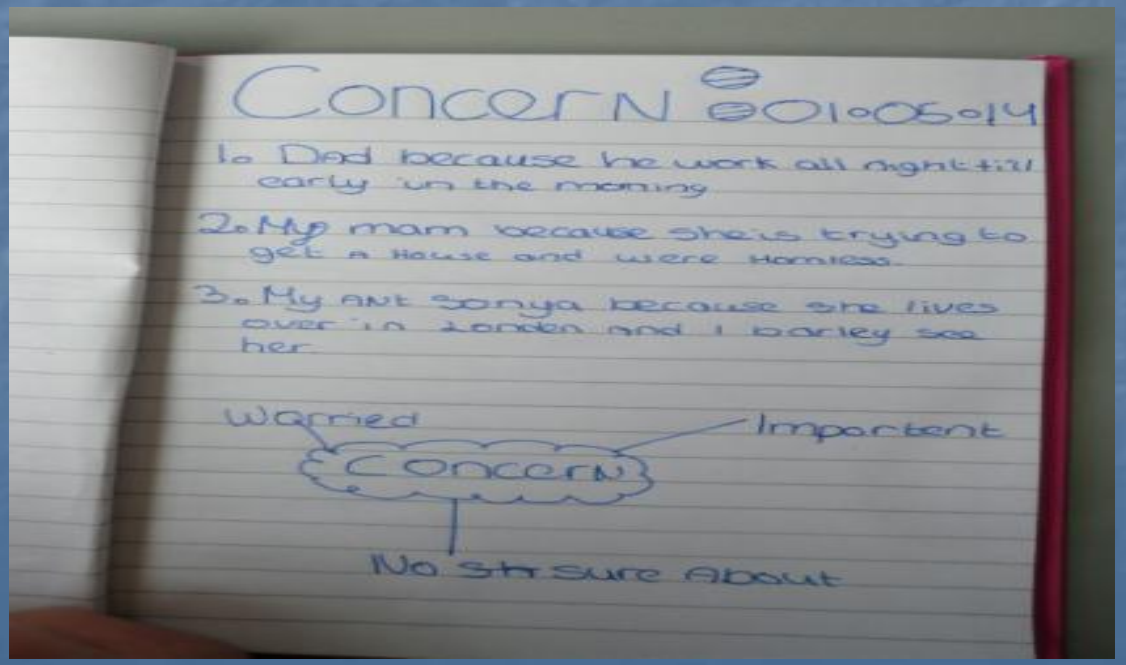
Boomer et al. (1992)

What is NIC?

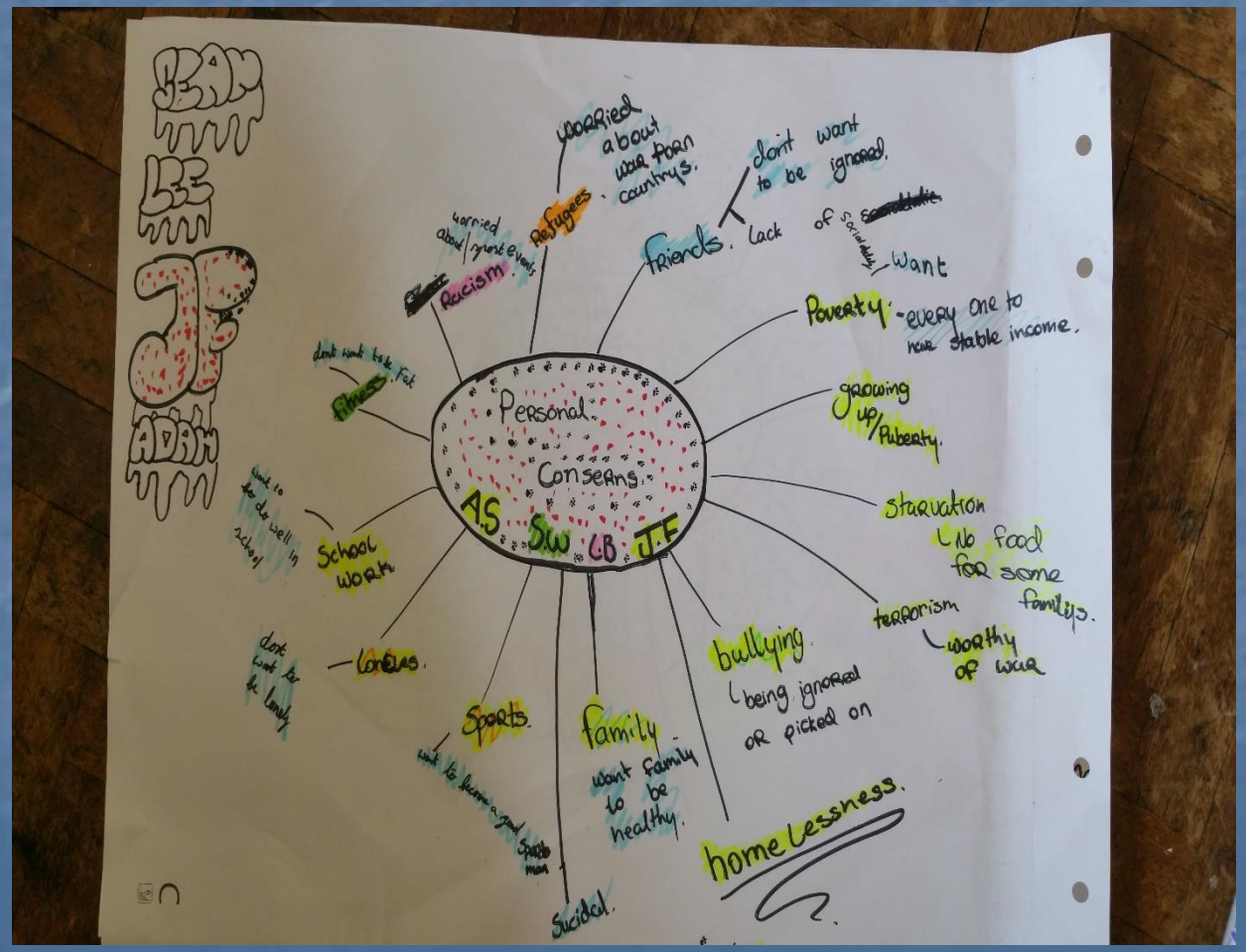
- All learning, to include what is learnt and how, is negotiated with students and focused on issues of concern to them
- Subjects are drawn upon as necessary to address the questions they generate in relation to their concerns
  - Learning from this is drawn together and synthesised in a NIC class - integrated
- In Sexton street this has been achieved in a two periods per week NIC session plus free classes
- Participating Schools
  - Galvone, Gaelscoil Shaoirse Clancy
  - CBS Sexton Street
  - Presentation (Nano Nagle), Salesians Pallaskenry, Laurel Hill

Step 1: What are your Individual Personal Concerns?

Students individually answered the question 'What are you concerned about yourself that you would like to learn more about this year?'

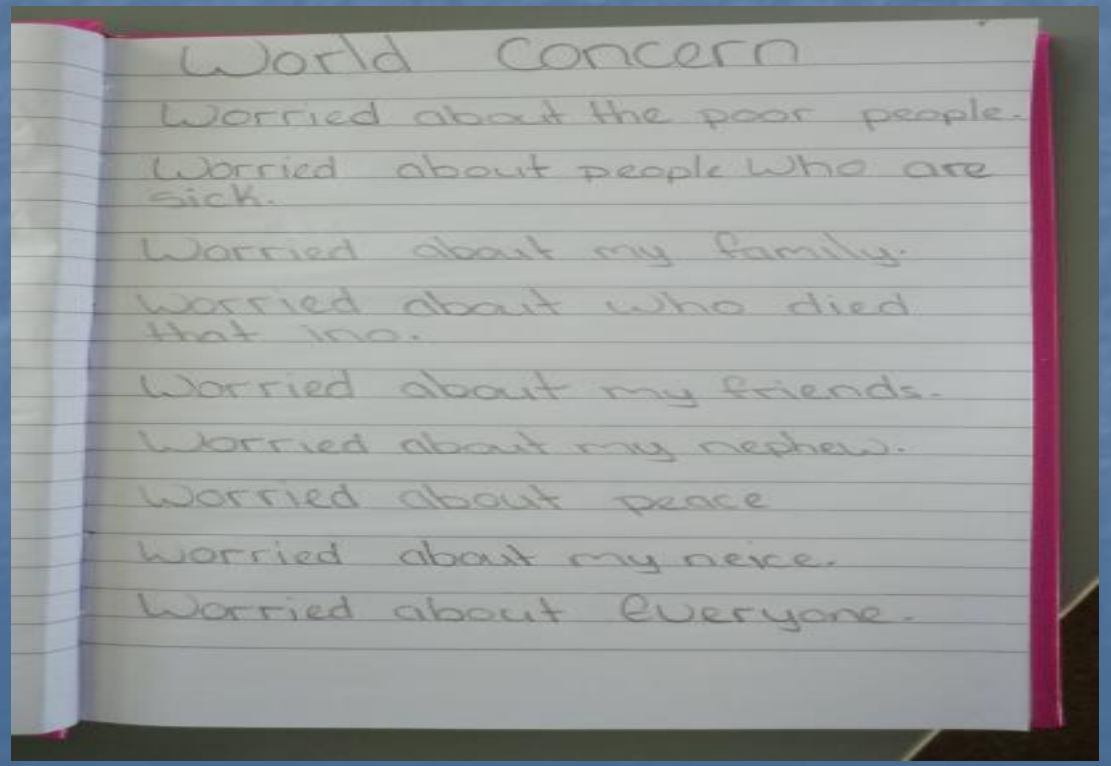


Step 2: Grouping Individual Concerns and Presentation

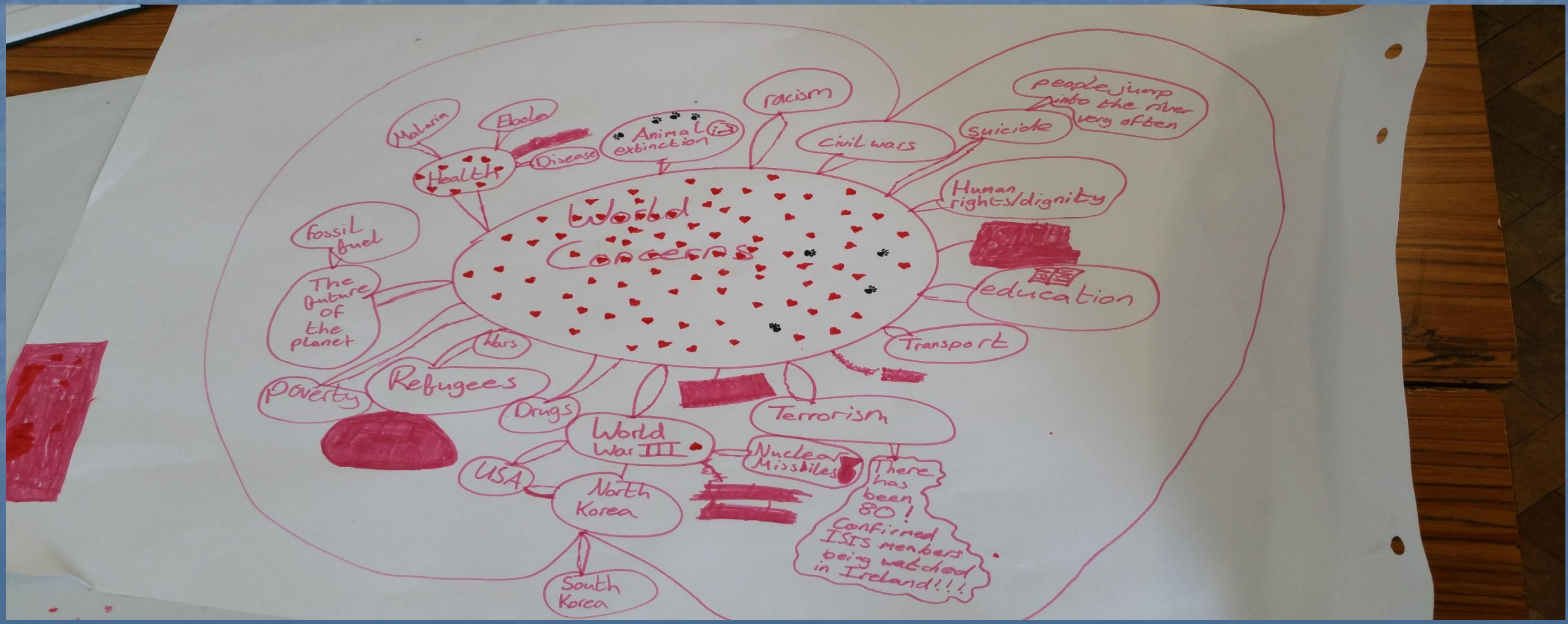


Step 3: What are your Individual World Concerns?

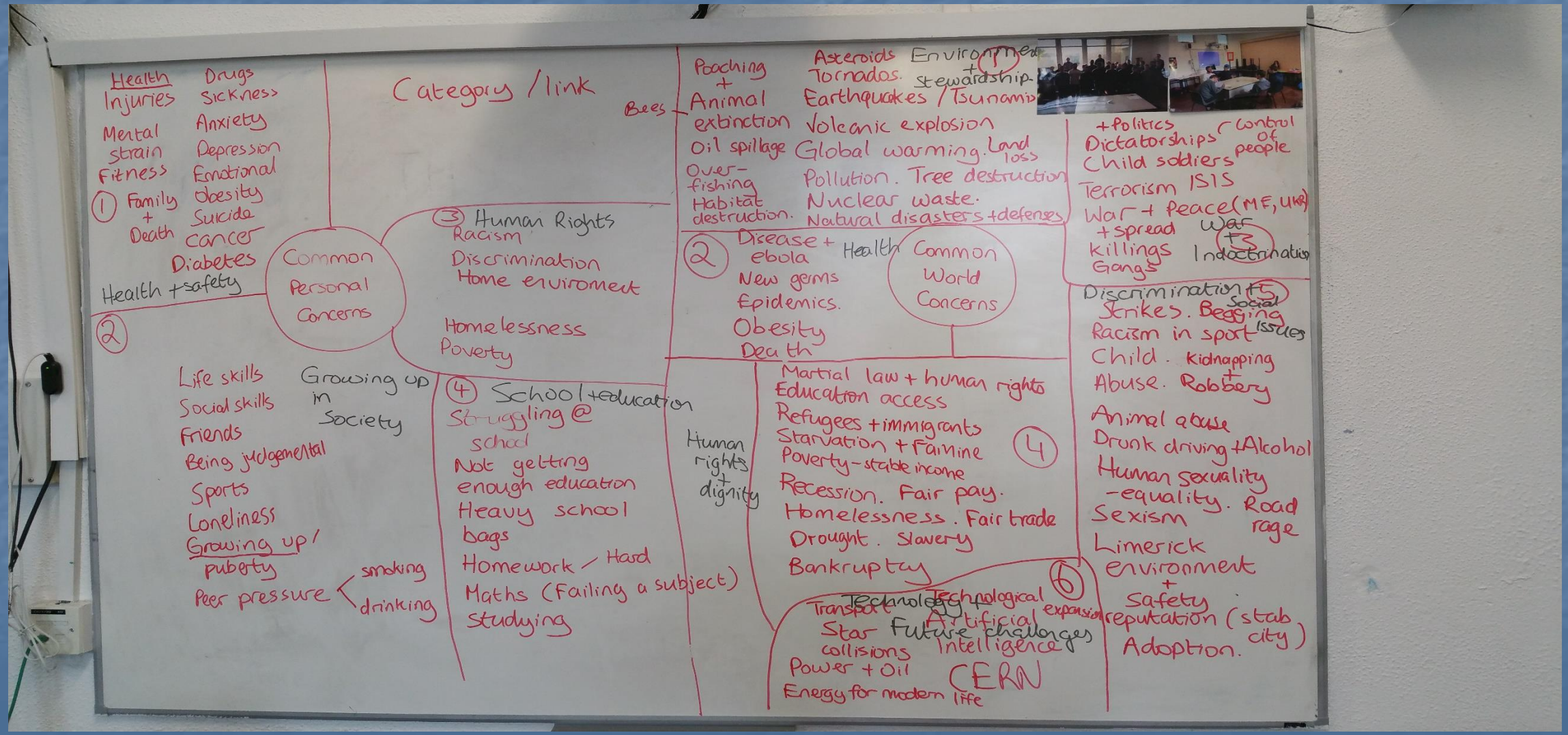
Students individually answered the question 'What are you concerned about the world around you that you would like to learn more about this year?'



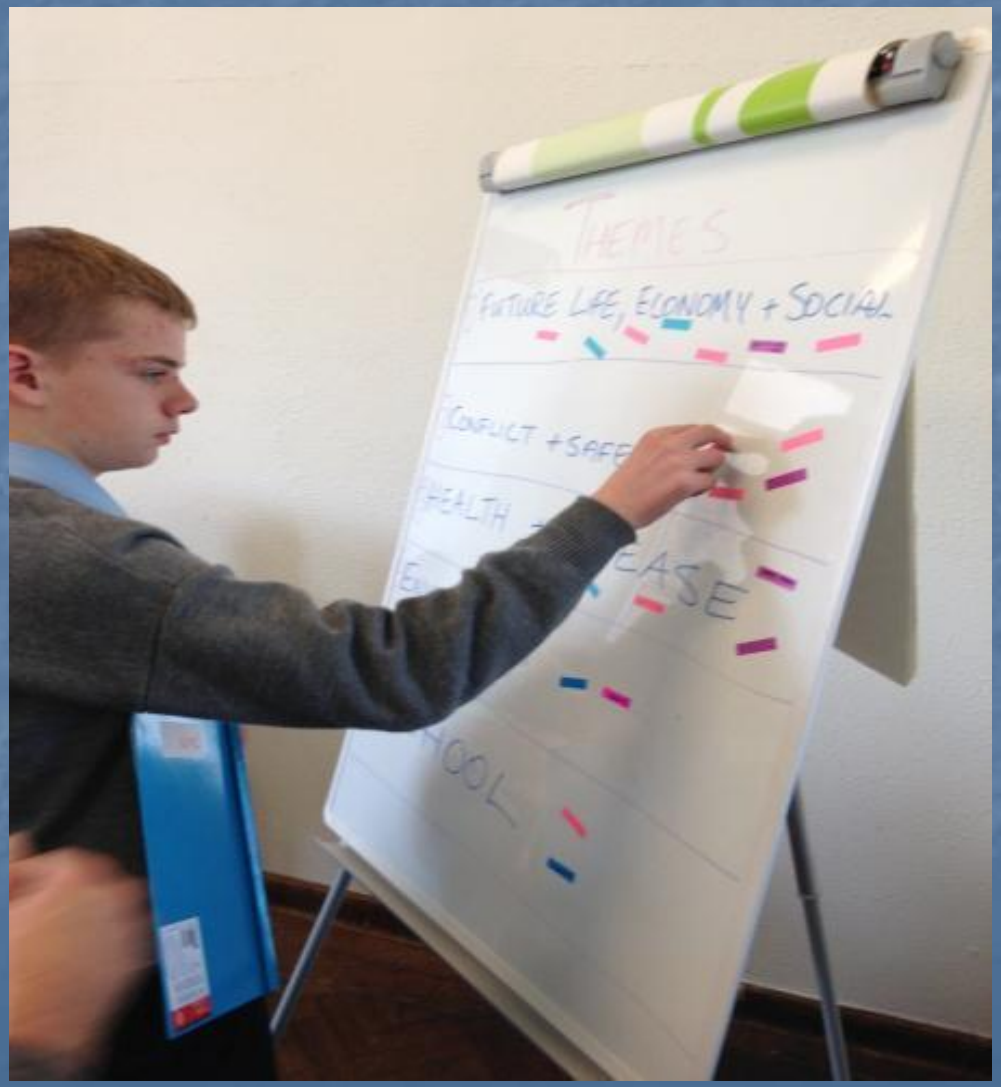
Step 4: Grouping World Concerns and Presentation



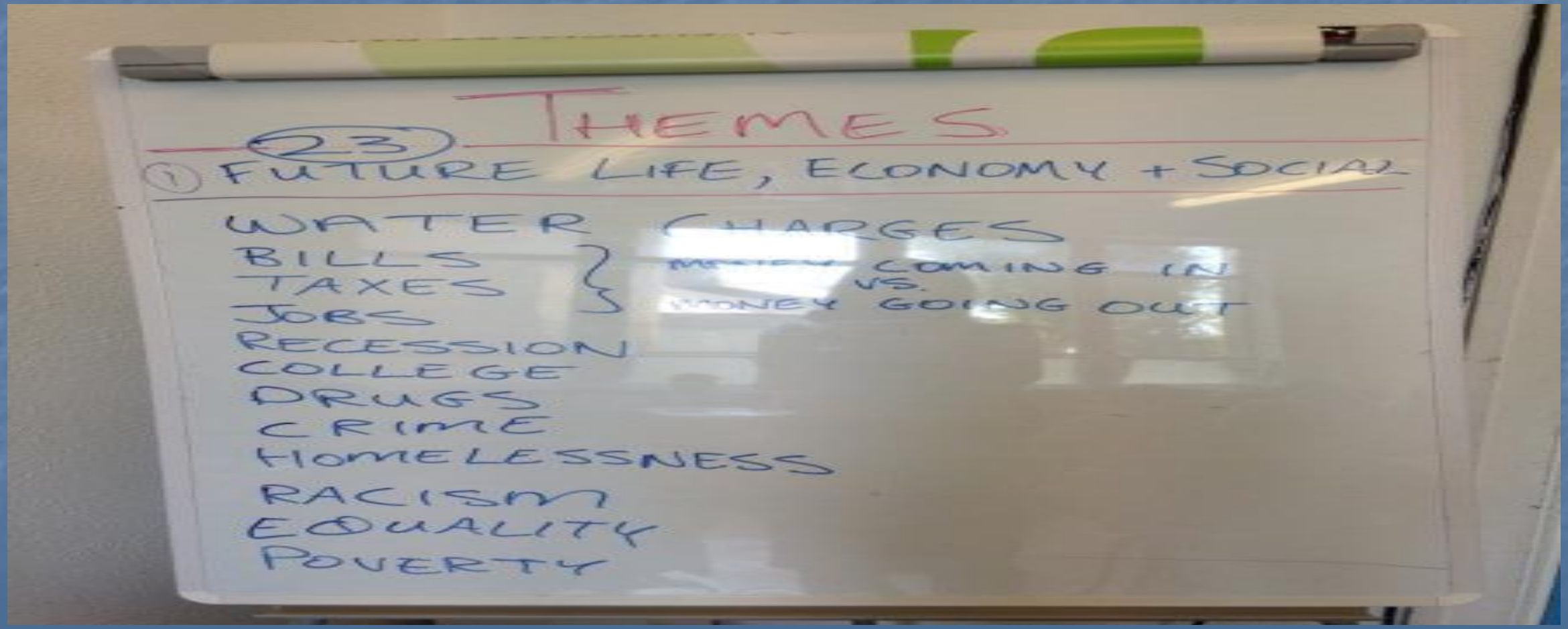
Step 5: Identifying Themes



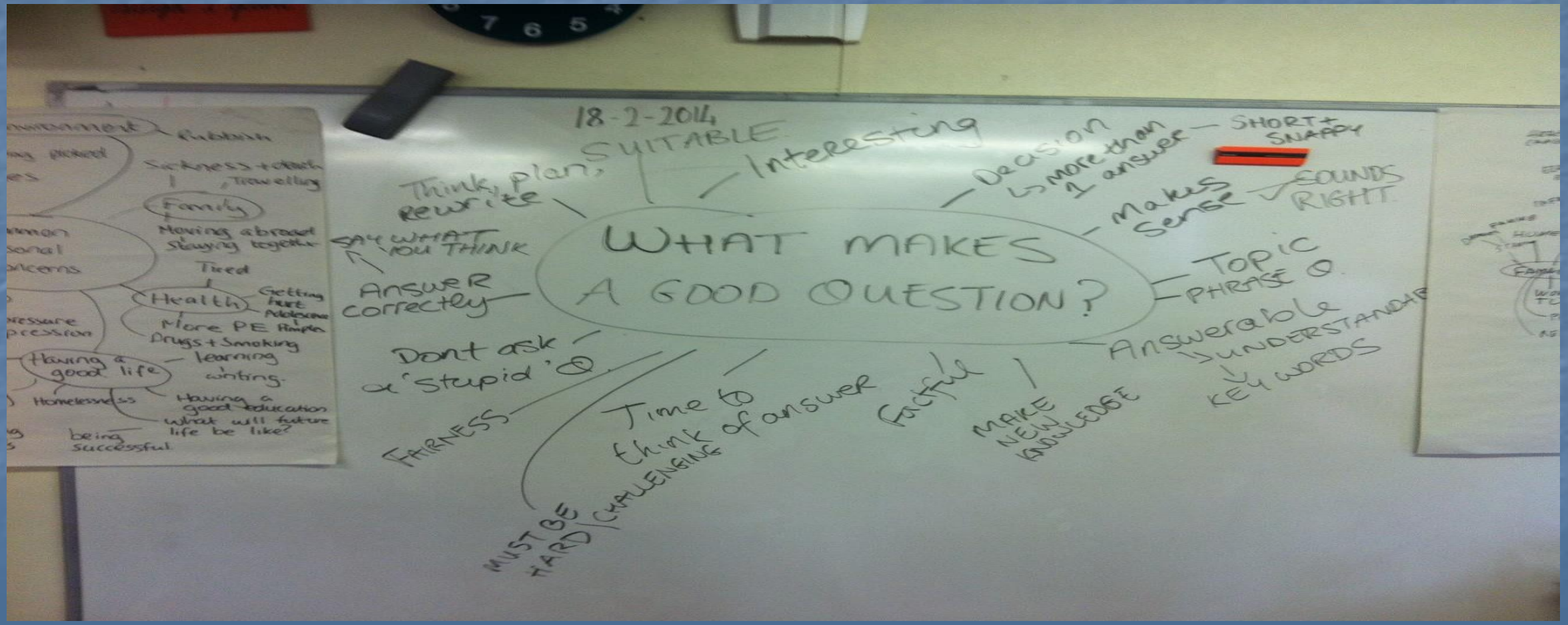
Step 6: Voting for Theme



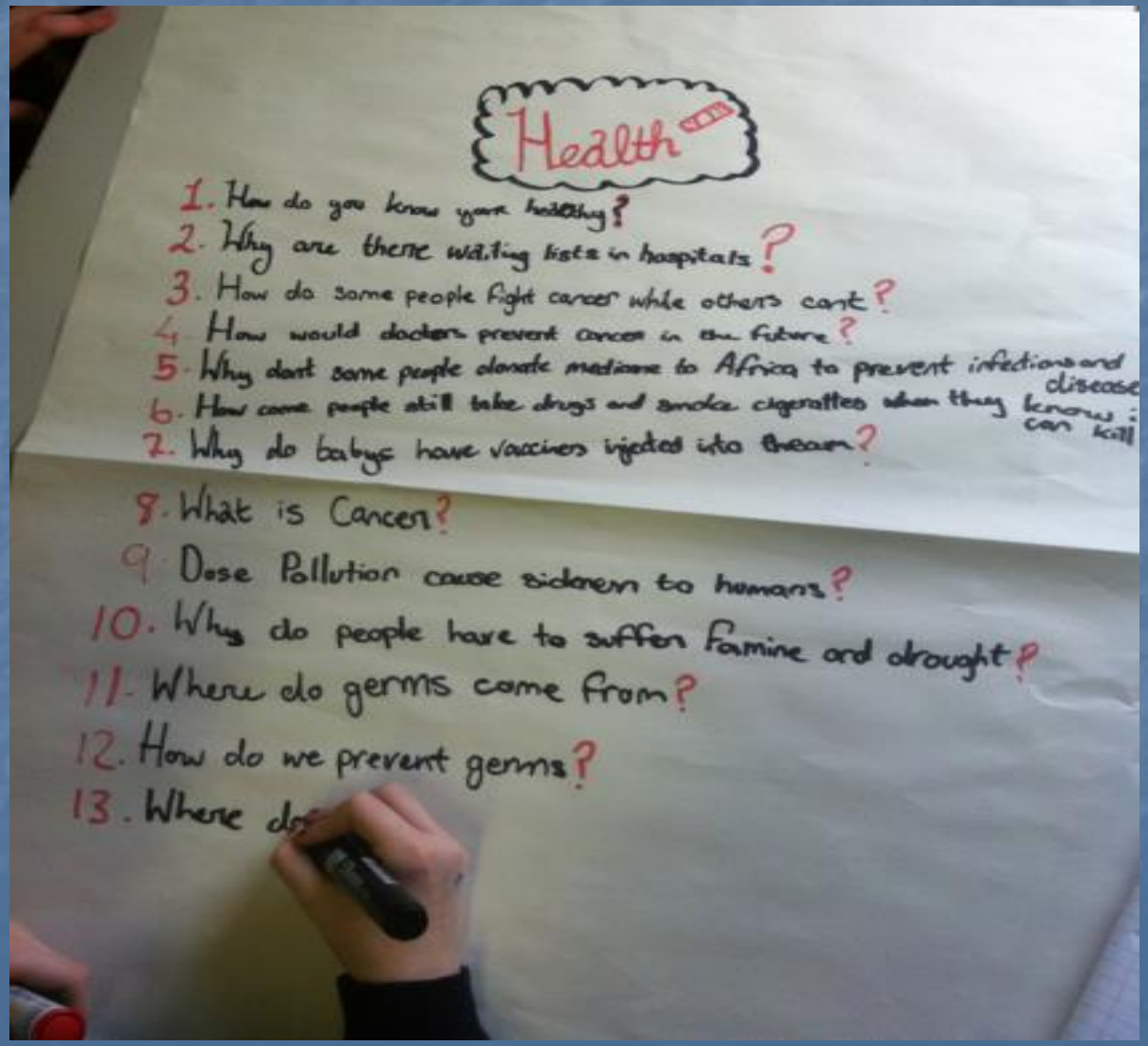
Listing key issues under theme



What makes a good question?



Step 7: Generating Questions



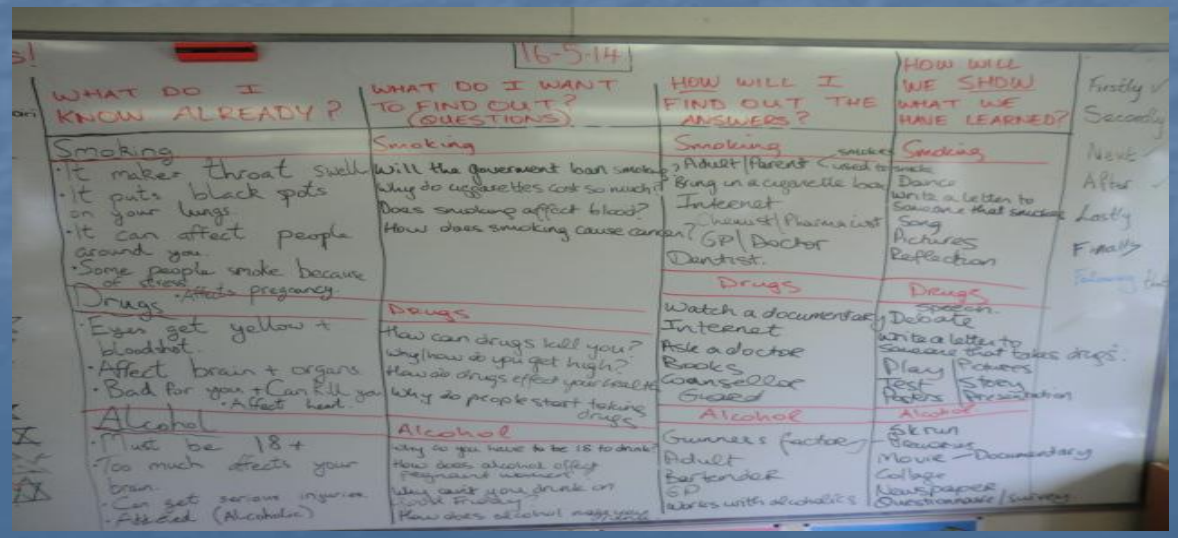
- Cut up questions and remove overlap
- Group questions under common sub-themes

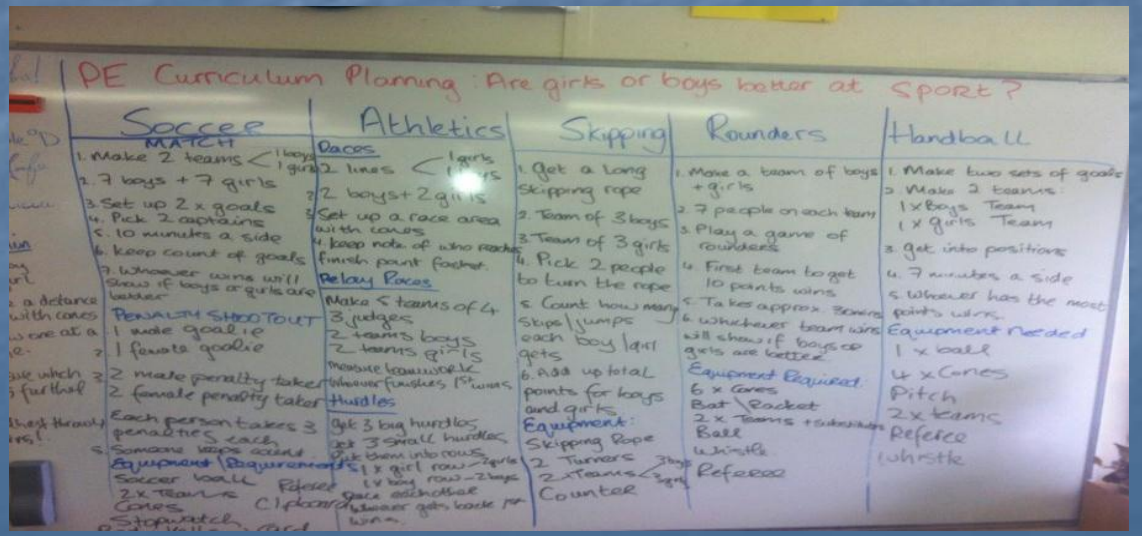
Step 8: Generating Activities to answer Questions

Step 9: Planning

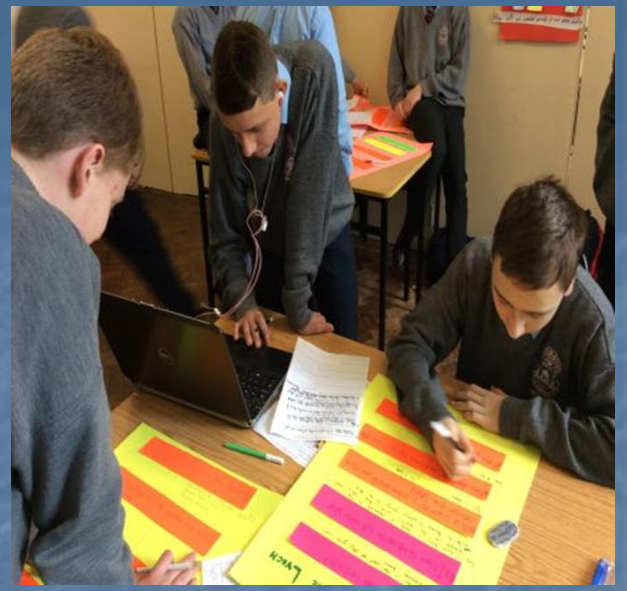
Ongoing work

- NIC sessions are used to plan, research and review
- Emphasis is on student responsibility and explanation of reasoning
- Learning is highly active and largely cooperative with an AfL focus
- Classroom teachers contribute expertise according to syllabus links

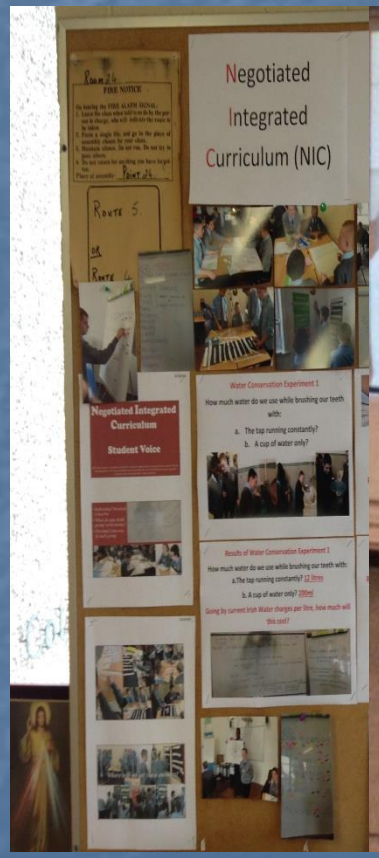


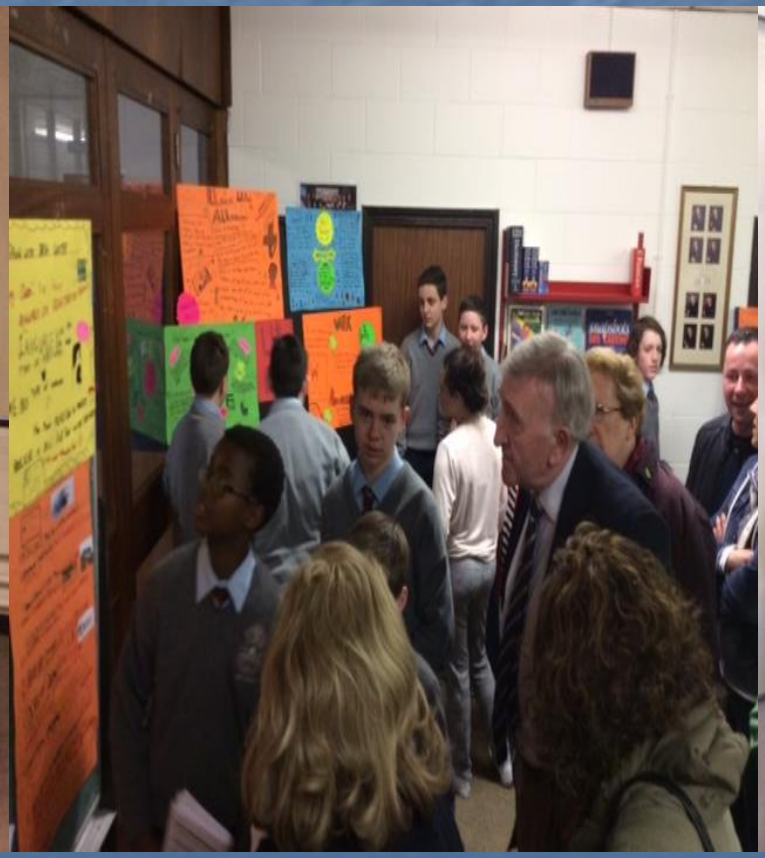



NEW LOOK



Work is celebrated around the school





Summary of key findings

- Schools act as knowledge builders
- Increased student agentic engagement across curriculum: initiative and investment
- Appreciation of agency and voice (both teacher and student)
- More student responsibility and confidence: changes in roles and expectations
- Capacity to differentiate
- Improvements in behaviour
- Frontloaded but acceleration occurs
- Ownership: meaning and purpose visible to all with practical approach

"I went into it with my eyes closed. I thought: they are only 12, what are they going to know? But I find now as a teacher we don't give them enough benefit for the knowledge they have……I have found that both in my business and my German classes, that they lead the way"

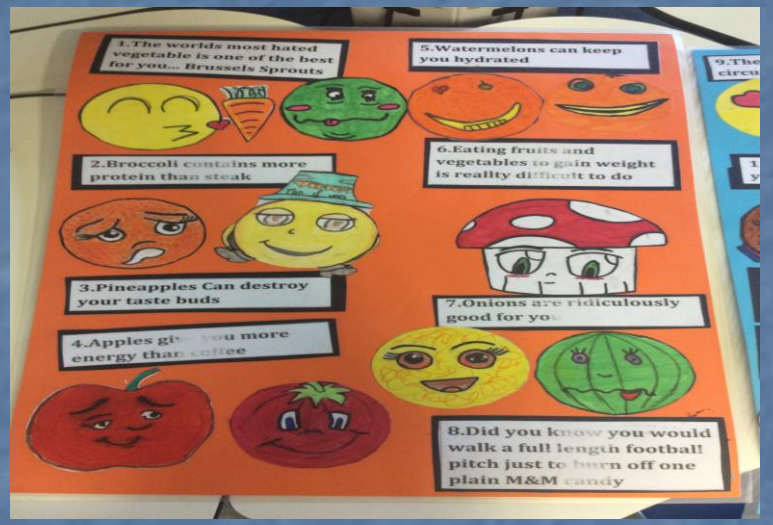
Suzanne Browne, CBS Sexton Street

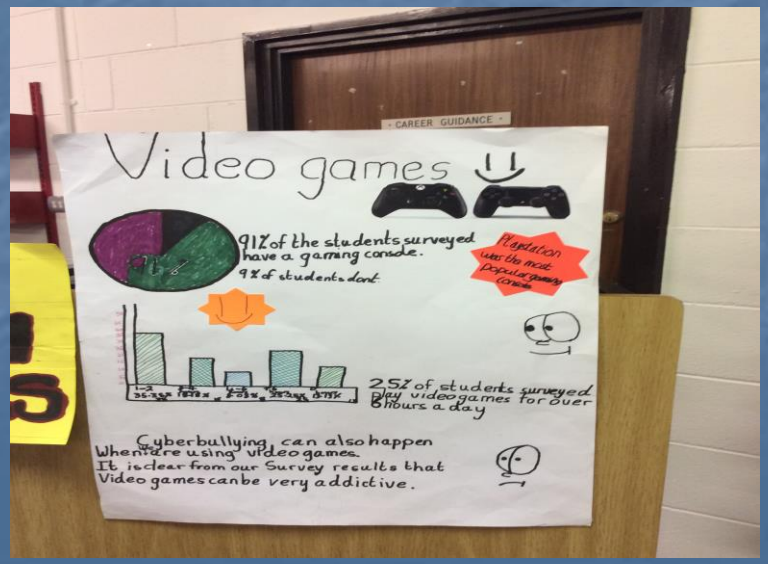
Irish Times "One student, one vote: democracy at work in the classroom"

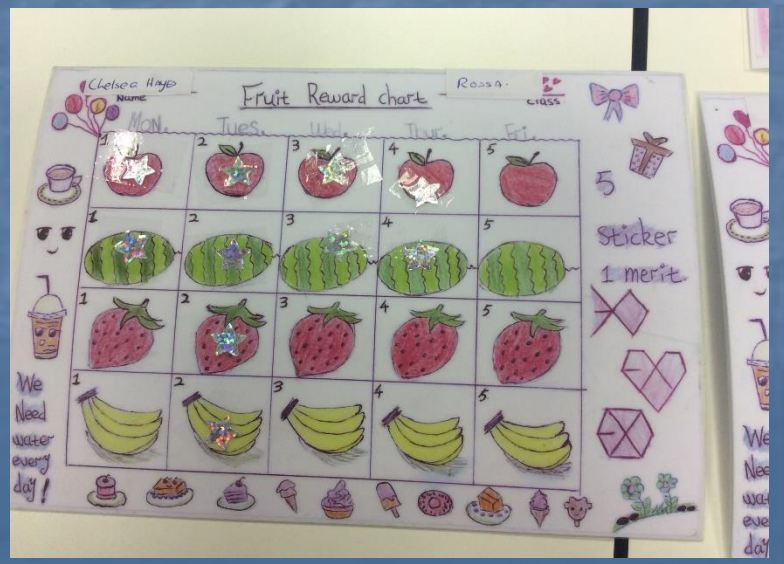
May 27th, 2015

Using NIC to generate STS themes

- Water charges
- Health
  - Obesity
  - Mobile phone use
  - Mental health
- High voltage cables
- Energy
- Climate Change
- GMOs







Irish Context

- Junior Cycle Framework
  - Democratic education, flexibility, wellbeing, key skills,….
  - JCF potentially represents a move from a "technical" to a "practical/emancipatory" curriculum (Morrison, 1995)
  - Short Courses provide space for NIC
- Science Specification
  - Open learning outcomes, no mandatory experiments, increased teacher autonomy, NoS and Earth and Space strands, levels of integration, Classroom Based Assessments

The need for Curricular Coherence

- "Currere": the course to be run
  - Alignment critical: Aim -> Learning Outcomes -> Learning Experiences -> Assessment
  - Assessment remains an issue
- Inquiry and Negotiation must permeate the curriculum (not just in science)
  - "Powerful Learning": IBL for 21st century skills (Darling-Hammond et al., 2015)
- SCs designed through NIC can create practical learning experiences to enable engagement and therefore motivation

Professional Development for IBSE

"No reported study has connected participation in inquiry-based PD with all the desired outcomes of teacher PD: enhanced teacher knowledge, change in beliefs and practice, and enhanced student achievement."

Recommendations:

- Support teachers in developing their own inquiry-based lessons
- Authentic Research experience
- Developing science content knowledge

Capps et al. (2012), p.291

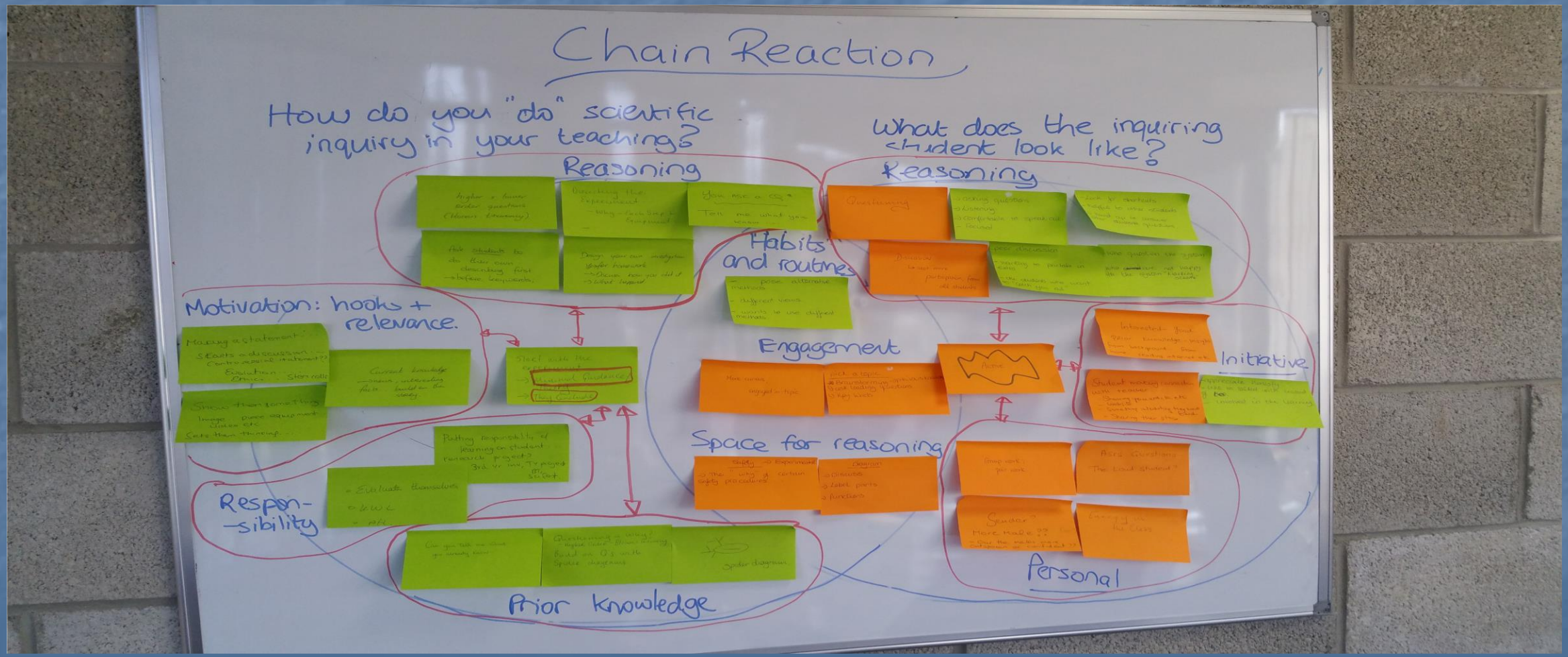
Role of Teacher Education

- Developing Professional Capital (PC)
  - *"Capital relates to one's own or group worth, particularly concerning assets that can be leveraged to accomplish desired goals"* (Hargreaves and Fullan, 2012, p.1)
  - Human: qualifications, skills, emotional intelligence in the individual
  - Social: relations between people – purpose, trust, collective responsibility , sharing human capital
  - Decisional: drawing on human and social capital to make good, discretionary judgements

Purpose of Teacher Education

- Develop the PC of teachers to inquire into their own (concerns about) practice in professional learning communities
  - Interrogate beliefs about role of teacher, student expectations and purpose
  - Articulate concerns and work on them cooperatively
  - Develop ownership and the habits of inquiry building on existing knowledge
  - Practical pedagogies that interrogate decision-making
  - Illuminate purpose, make understandings visible & reflect

Teacher Perspectives on IBSE



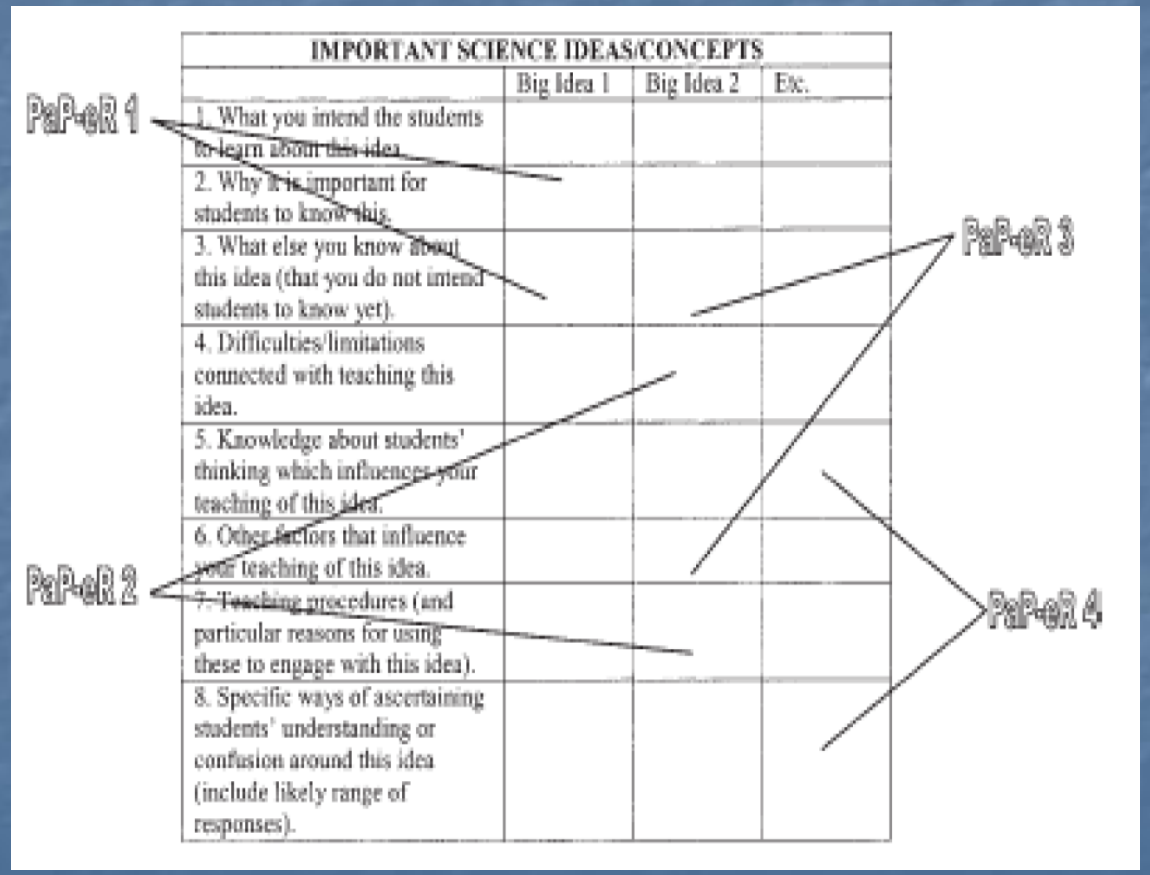
Chain Reaction (2015)

Pedagogical Content Knowledge (PCK)

"This implies that professional development programs aimed at the development of teachers' PCK cannot be limited to supplying teachers with input, such as examples of expert teaching of subject matter. Instead, such programs should be closely aligned to teachers' professional practice and, in addition to providing teachers with specific input, should include opportunities to enact certain instructional strategies and to reflect, individually and collectively, on their experiences."

Van Driel and Berry (2012)

PCK description



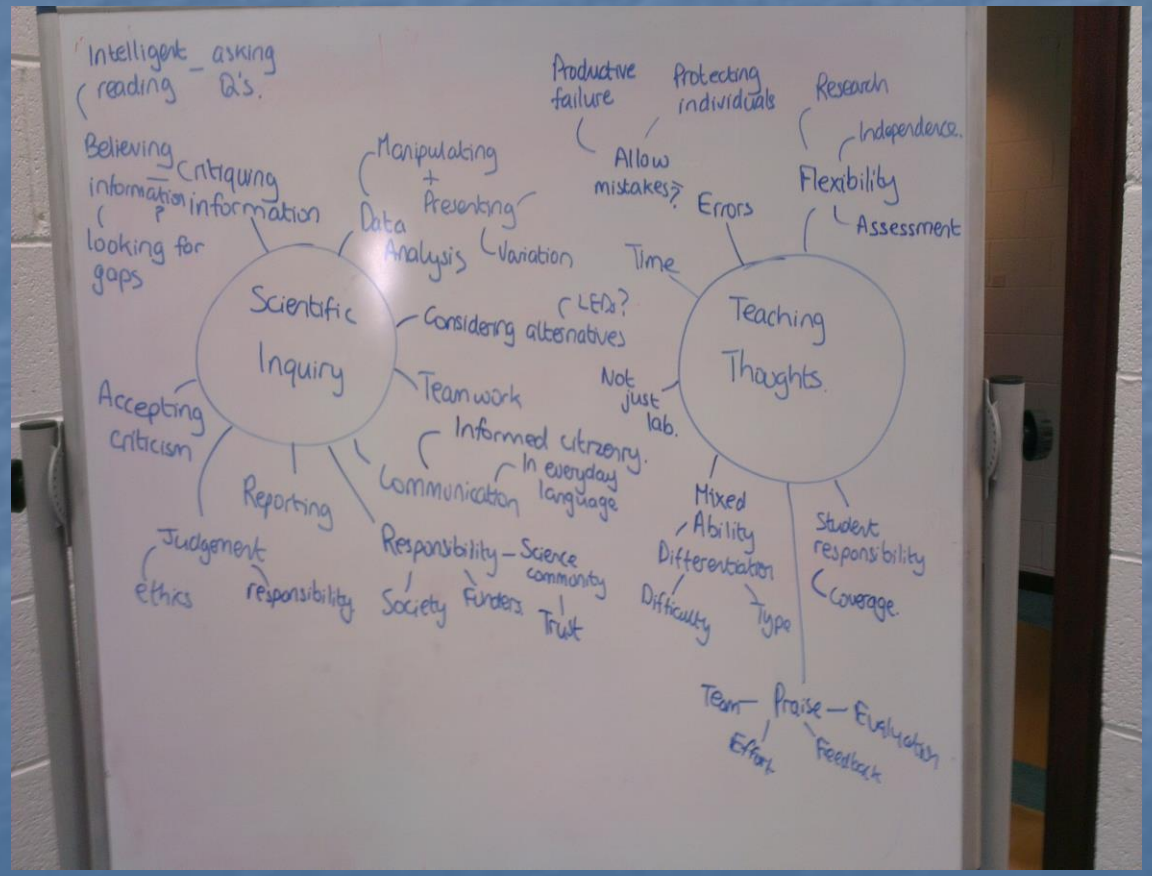
IMPORTANT SCIENCE IDEAS/CONCEPTS			
	Big Idea 1	Big Idea 2	Etc.
1. What you intend the students to learn about this idea.			
2. Why it is important for students to know this.			
3. What else you know about this idea (that you do not intend students to know yet).			
4. Difficulties/limitations connected with teaching this idea.			
5. Knowledge about students' thinking which influences your teaching of this idea.			
6. Other factors that influence your teaching of this idea.			
7. Teaching procedures (and particular reasons for using these to engage with this idea).			
8. Specific ways of ascertaining students' understanding or confusion around this idea (include likely range of responses).			

- CoRe can make IBSE reasoning visible and subject to development: human and social capital
- Modelling can be followed by students cooperating on CoRe development
- Potential to be applied to (most challenging) Learning Outcomes of new specification
- Can form part of SSE process

Loughran et al. (2004)

Lesson Study

- Tutor models IBSE lesson with teachers as learners
- Lesson is then analysed and critiqued
- ITE students can take responsibility
- Practising teachers can observe classes as critical friends



Cheung et al. (2014)

Conclusions

- Proposition: IBSE will not be achieved without a broad, inquiry-based approach across the curriculum
- Students should be involved in negotiating aspects of their learning to activate their agentic engagement
- Teachers will have agency for this purpose given the opportunity to engage with practical structures to realise same
- PD must focus on developing PC

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