TOWARDS A FOCUS ON TRANSDISCIPLINARITY IN CHEMISTRY EDUCATION

Jack Holbrook

Centre for Science Education

University of Tartu

A VISION OF CHEMISTRY EDUCATION

There has been a shift in the orientation of chemistry teaching

from visualising

* Learning as a **body of knowledge** (*conceptualisations of the subject matter*)

to purpose

* Promoting **contextualization** - *science for relevance* (Gilbert, 2006; Holbrook & Rannikmäe, 2009)
* Instilling **responsibility** - *role of chemistry within society)* (Holbrook & Rannikmäe, 2010)
* Recognising **interdisciplinarity** as moving from sub-disciplines to **interrelationships**,
* Promoting the need for **career awareness** (Horizon 2020 - Multico project), and
* Portraying the **role of chemistry for the world of the future** (*Education for Sustainability*).

DEFINING
Scientific and Technological Literacy

This can be portrayed throough the conceptualisation of Chemistry literacy e.g.

“Away from isolated chemistry conceptualisations into d*eveloping the ability to creatively utilise sound chemistry knowledge in everyday life, or in a career, to solve problems, make decisions and hence improve the quality of life.”*

(Holbrook and Rannikmae , 1997)

UNIVERSITY OF TARTU
1632

Perceiving Scientific and Technological Literacy

This can be portrayed through the conceptualisation of Chemistry literacy e.g.

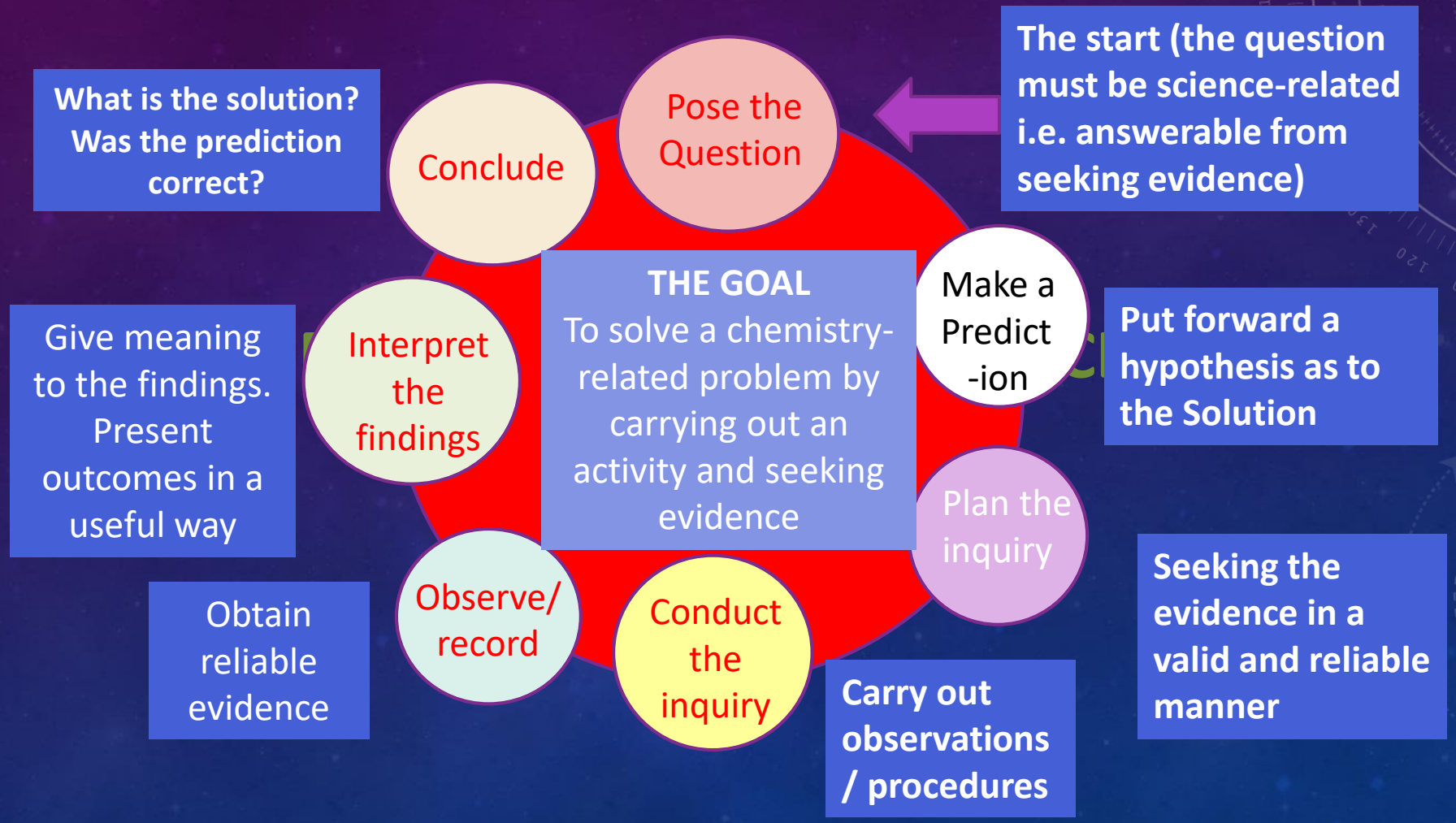
“Away from isolated chemistry conceptualisations into *developing the ability to creatively utilise sound chemistry knowledge in everyday life, or in a career, to solve problems, make decisions and hence improve the quality of life.”*

(Holbrook and Rannikmae , 1997)

A Generally Perceived Focus of Chemistry Literacy

- Knowledge of the substantive content of chemistry.
- Conceptualising chemistry and its applications.
- Ability to use chemistry knowledge in problem solving.
- Ability to think critically about and develop chemistry expertise.
- Appreciation of, and comfort with, chemistry, including its wonder and curiosity.
- Understanding the nature of science, including its relationship with culture.
- Knowledge of the risks and benefits of chemistry.
- Independence/self initiative in learning chemistry.
- Knowledge needed for intelligent participation in science-based issues.

AN INQUIRY (PROBLEM-BASED) CYCLE IN CHEMISTRY



UNIVERSITY OF TARTU
1632

BUT
- the Learning Approach in Chemistry!!

- is it

CHEMISTRY THROUGH EDUCATION

where the focus is on the **chemistry subject** learning?

OR

EDUCATION THROUGH CHEMISTRY

where the focus is on the **educational gains** e.g. conceptualisation through self determination, self evaluation, extending the ‘Zone of Proximal Development’ (Vygotsky, 1978)

Science through Education (focus on the science)	Education through Science (focus on the educational gain through science)
Learn fundamental science knowledge, concepts, theories and laws.	Learn the science knowledge and concepts important for understanding and handling *socio-scientific issues within society.*
Undertake the processes of science through inquiry learning as part of the development of learning to be a scientist.	Undertake investigatory scientific problem solving to better understand the science background *related to socio-scientific issues within society.*
Gain an appreciation of the nature of science from a scientist's point of view.	Gain an appreciation of the nature of science from a societal point of view.
Undertake practical work and appreciate the work of scientists.	Develop personal skills related to creativity, initiative, safe working, etc.
Develop positive attitudes towards science and scientists.	Develop positive attitudes towards science as a major factor in the development of society and scientific endeavours.
Acquire communicative skills re- oral, written and symbolic/tabular/ graphical formats as part of systematic science learning.	Acquire communicative skills related to oral, written and symbolic/tabular/ graphical formats to better express scientific ideas in a social context.
Undertake decision making in tackling scientific issues.	Undertake socio-scientific decision making related to issues arising from the society.
Apply the uses of science to society and appreciate ethical issues faced by scientists.	Develop social values related to becoming a responsible citizen and undertaking science-related careers.

Introducing Interdisciplinary Chemistry Education

Based on a plethora of research-based evidence, interdisciplinarity research enables the bringing together of:

- ***Design-based learning;***
- ***Problem solving and the gains from project based approaches to develop scientific competences;***
- ***Involving, where appropriate, mathematical/digital learning;***
- ***Enabling a science in society approach to the curriculum.***

BUT A possible question – is this enough?

To reflect on Science Education for, and within, the Future Society

(e.g. *Science Education for a Sustainable Future*),

does science education research need to embrace more than interdisciplinarity**?**

UNIVERSITY OF TARTU

Introducing

A TRANSDISCIPLINARY APPROACH TO CHEMISTRY EDUCATION

To reflect on Chemistry Education for and with the Future Society

(Science Education for a Sustainable Future),

it is proposed chemistry education research need to embrace

Transdisciplinary Education?

How does this differ from INTERDISCIPLINARY?

Trans-disciplinarity

Alfonso Montuori (2008, p. ix) wrote in the foreword to his book about trans-disciplinarity

"Trans-disciplinarity is perhaps, above all, a new way of thinking about, and engaging in, inquiry."

***Chemistry education operates through action within science-related learning areas, seeking solutions, or considering issues that affect us plus the decision making thinking to resolve or mitigate against the issues*.**

A chemistry approach **through transdisciplinarity** lends itself to a **'science within society'** perspective and to establishing an approach to raise awareness of the need to tackle *socio-scientific issues which impact on society* and *on* responsible citizenry, plus enhance *related - employability skill perceptions*.

REFLECTING ON THE CHANGE OF LEARNING EMPHASIS

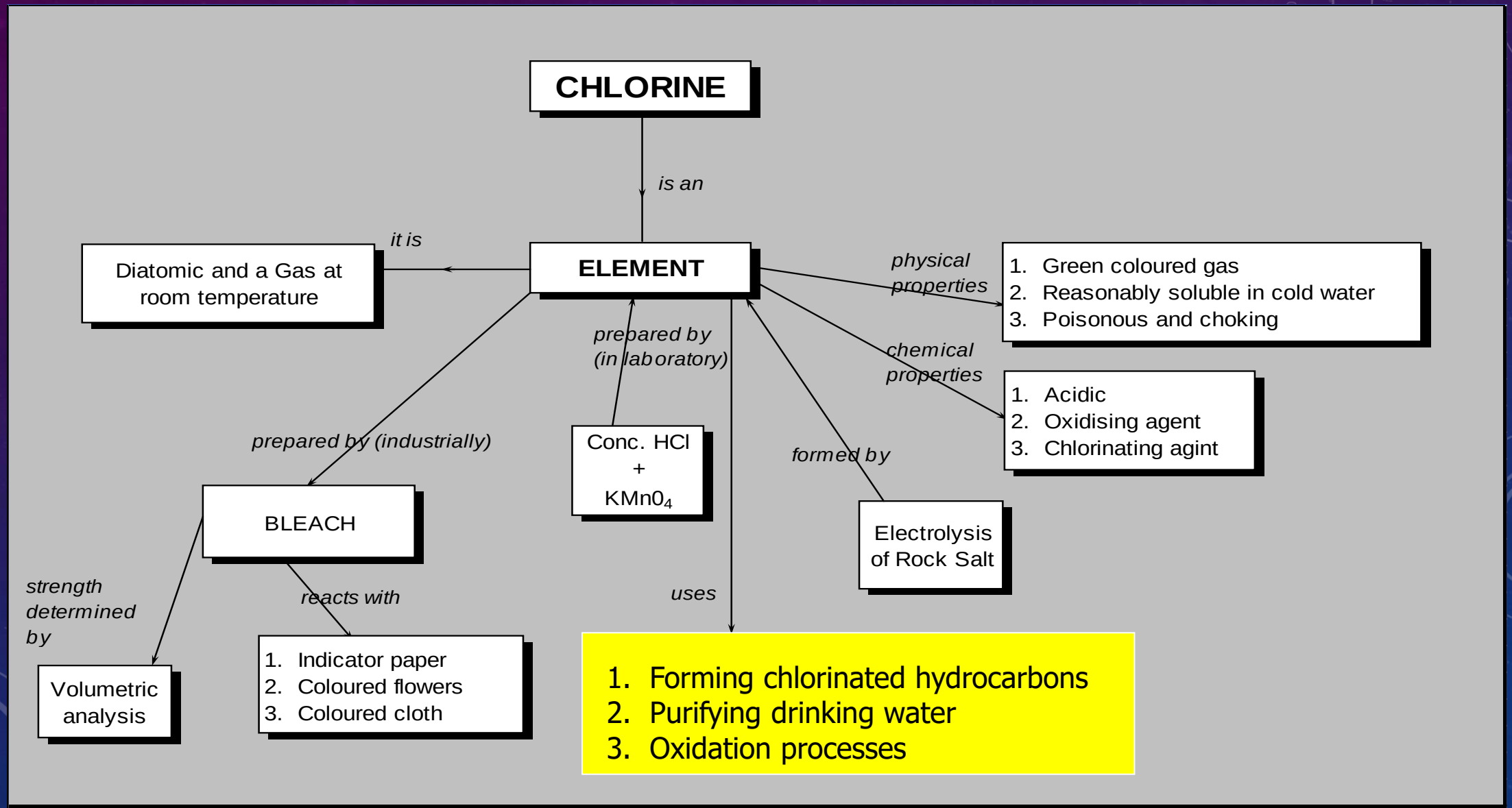
The following example is a sequence of school chemistry lessons (Holbrook, 2005) seeking to refocus learning and engage with society issues.

I seeks to shift the curriculum topic from simply based on conceptual ideas, and alternatively incorporate other aspects considered to be relevant or of value e.g.

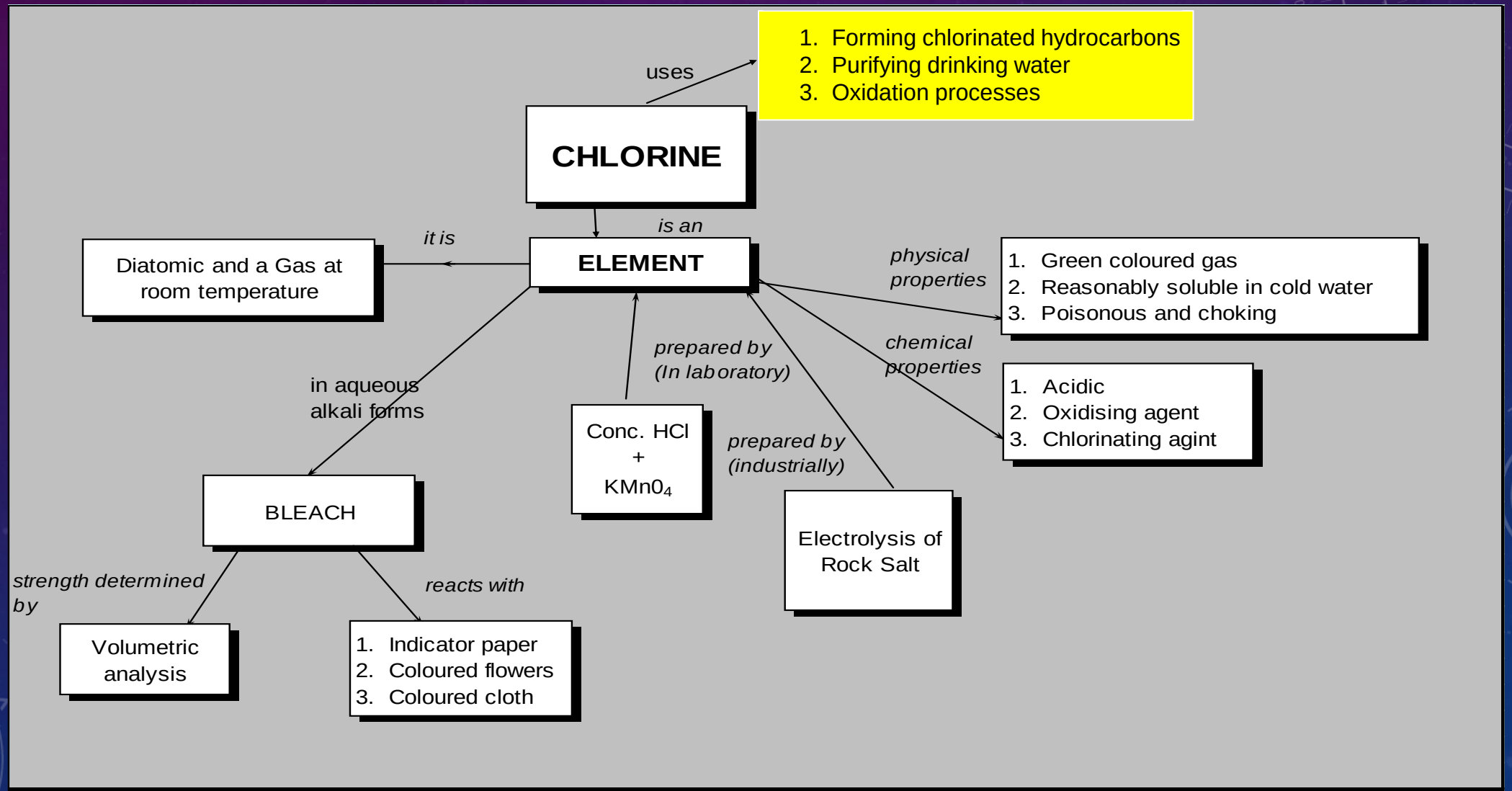
society concerns; society situated learning; career awareness.

interdisciplinary skills, such as problem solving; decision making; communication skills; - collaboration with others; self-actualisation).

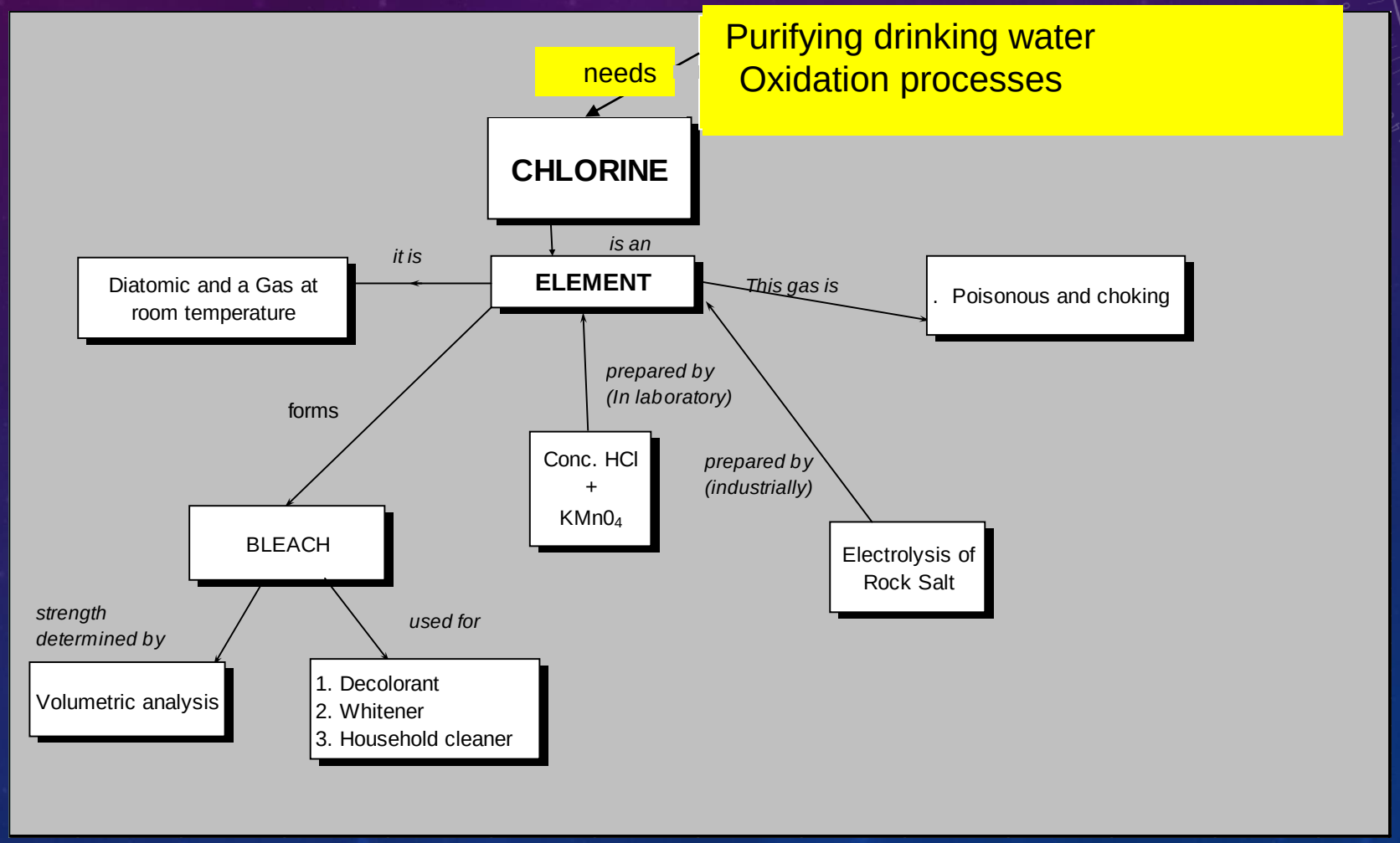
A POSSIBLE CHLORINE CONCEPT MAP



TRANSFORMING THE APPROACH (STEP 1) – THE APPLICATION 1ST RATHER THAN LAST!)

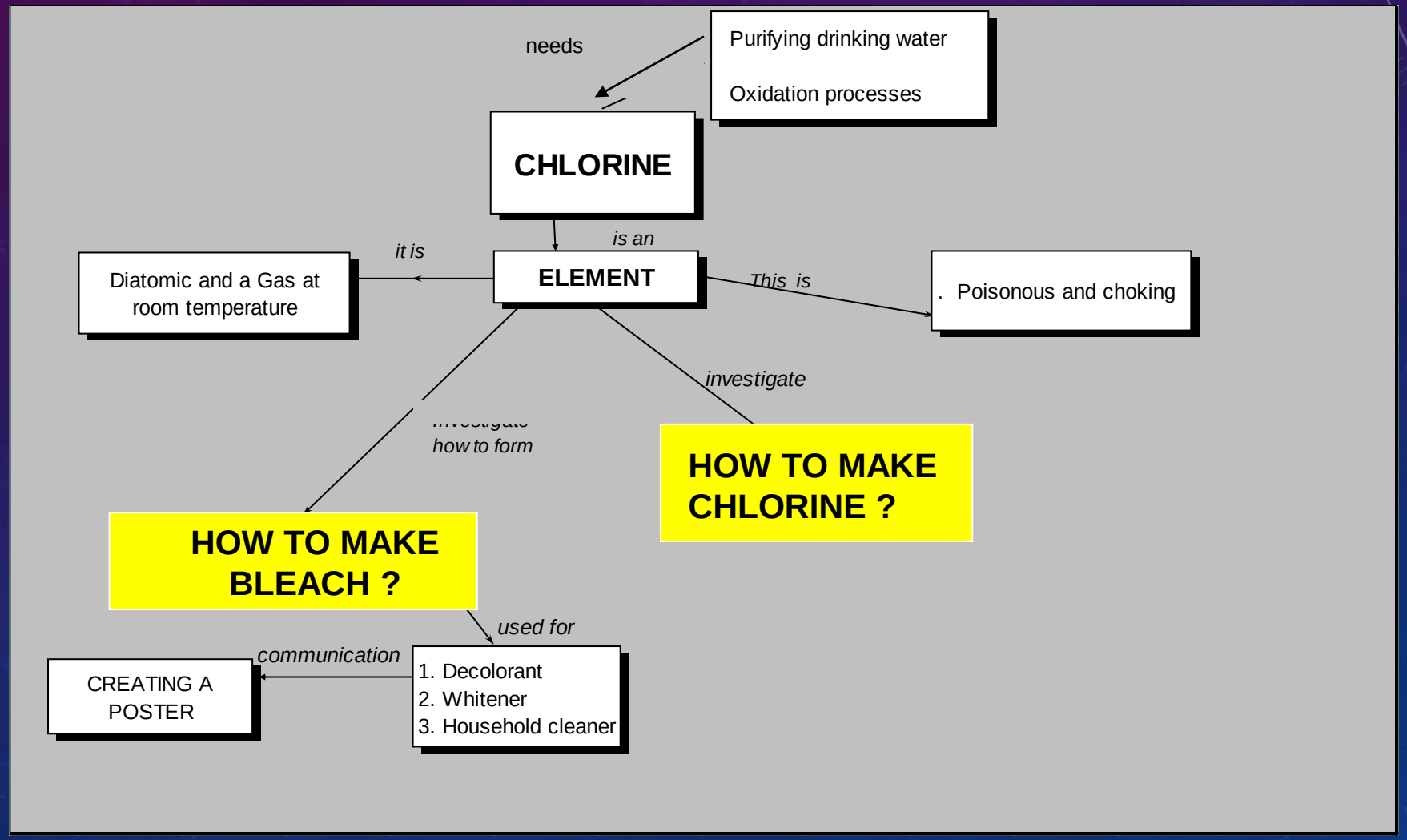


TRANSFORMING THE FOCUS (TAKING A SPECIFIC SOCIETY FOCUS)



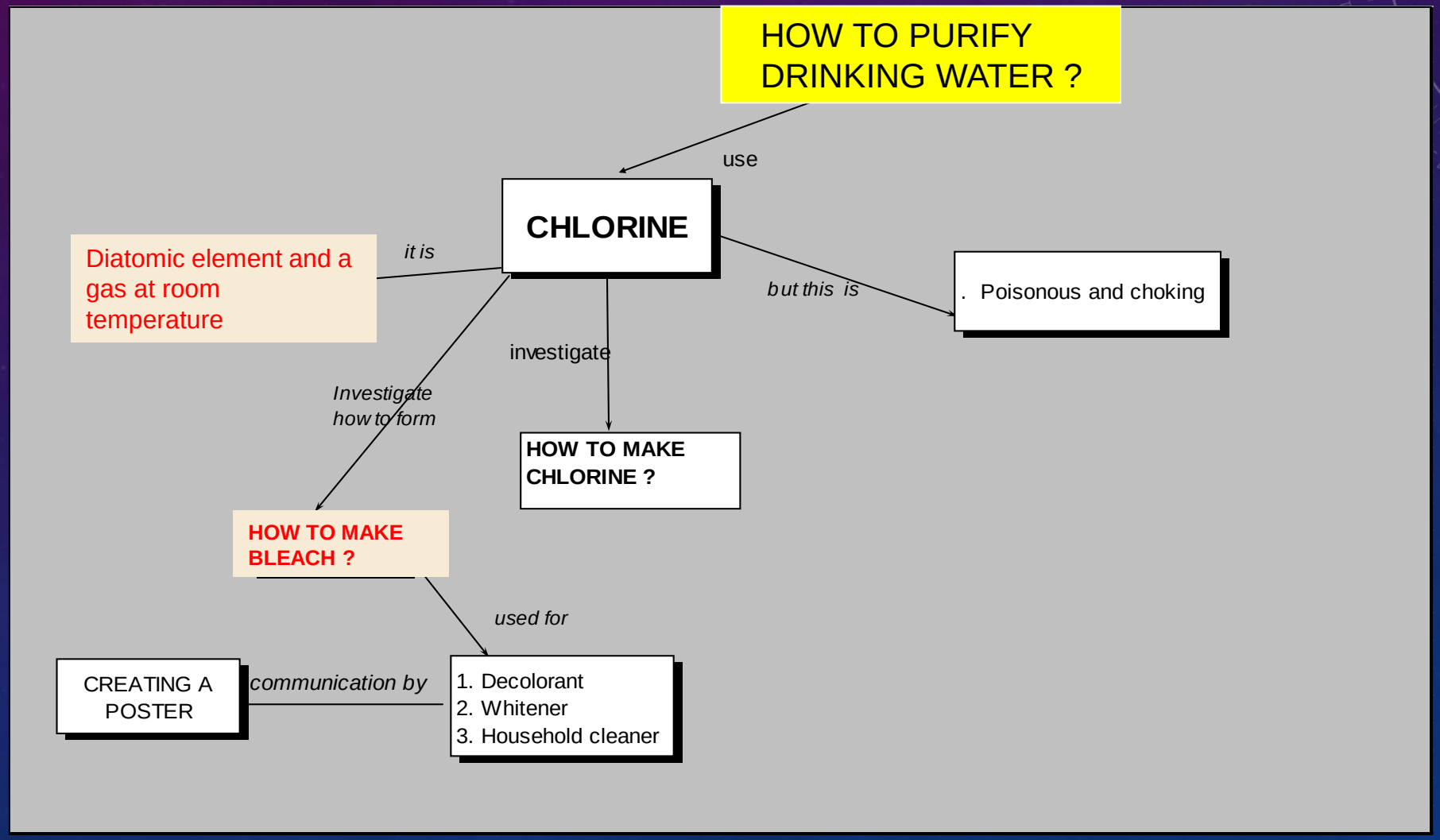
ADDING PROBLEM SOLVING (STUDENT INQUIRY)

(BUT STILL A FOCUS ON INTELLECTUAL COMPETENCES)

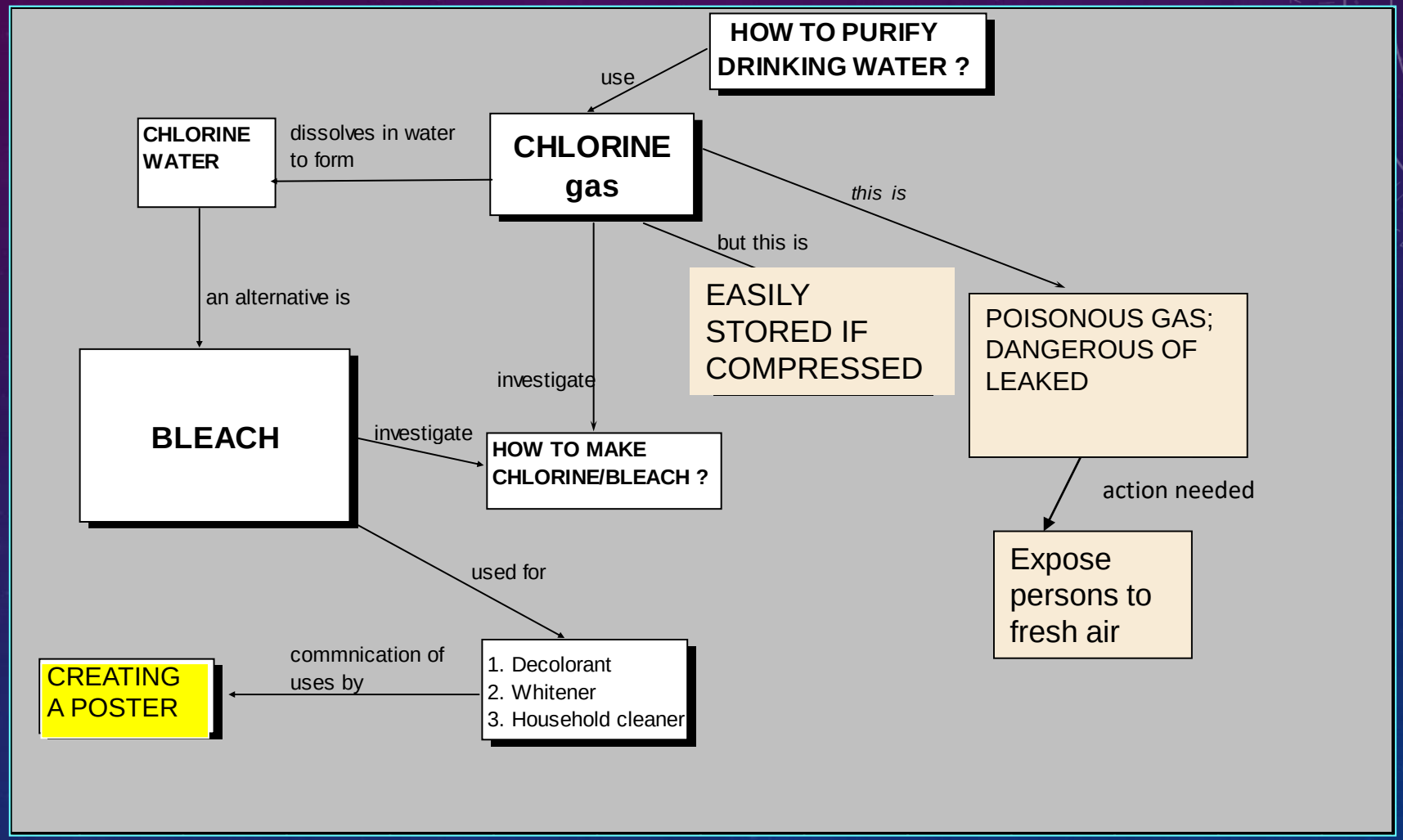


INTRODUCING A RELEVANT INQUIRY FOR A SOCIETAL CONCERN

INSTEAD OF AN EXAMPLE OF CHLORINE USE –
THE INITIAL FOCUS IS NOW **THE SOCIETY CONCERN**



MAKING THE CHEMISTRY MORE SOCIETY RELEVANT AND ADDING CREATIVE COMPETENCES

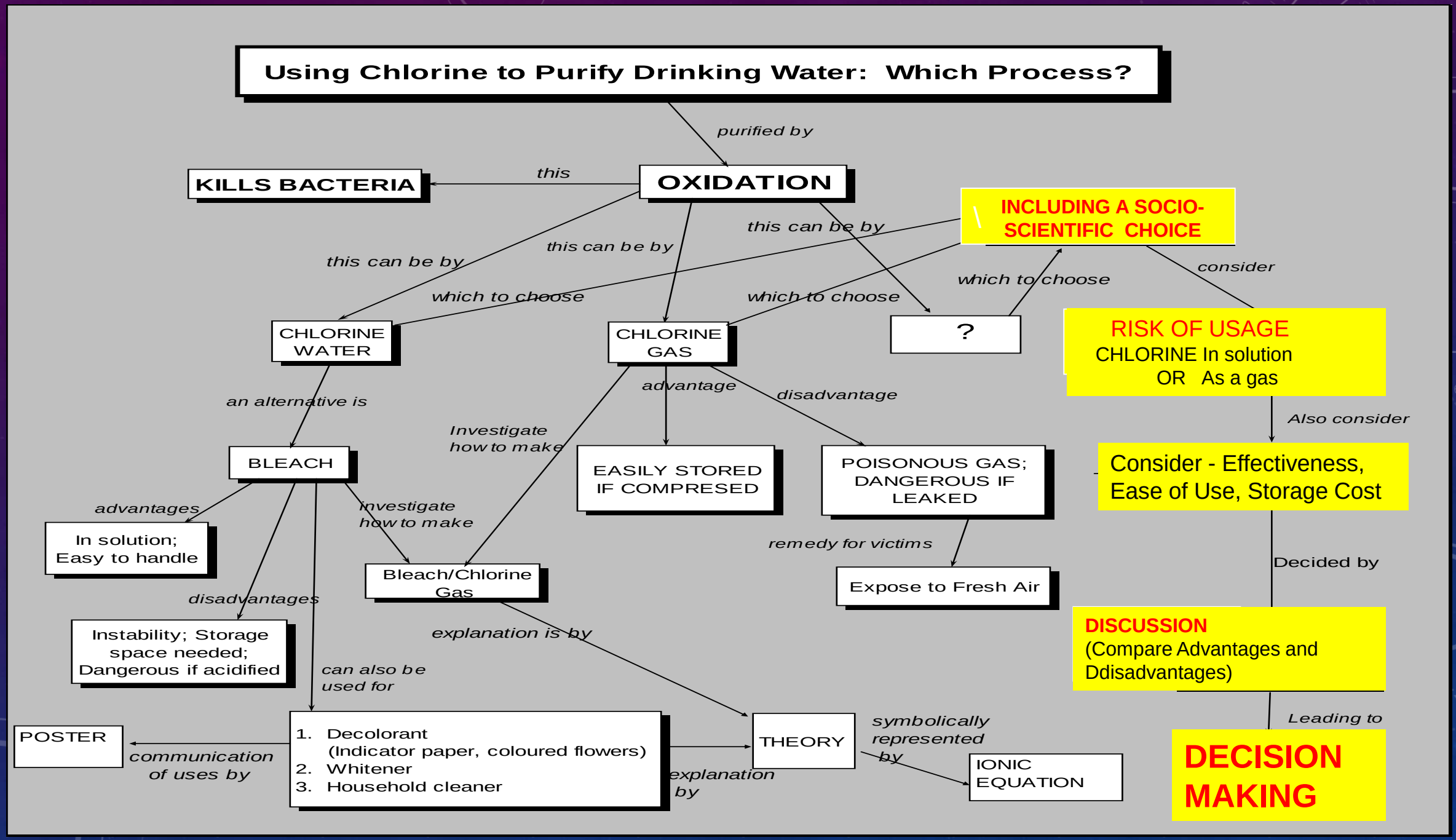


AND NOW, POTENTIALLY, A MORE COMPLETE CHANGE

FROM A MAP SHOWING THE CHEMISTRY CONCEPTS

TO A map showing the conceptual learning, the competence challenges and a potentially more **societal teaching approach**

The focus now being on promoting a wider range of Competences seen as 'VASK' – values, attitudes, skills, knowledge)
(Council of Europe; OECD, 2015)


Using Chlorine to Purify Drinking Water: Which Process?
purified by
this
KILLS BACTERIA
OXIDATION
INCLUDING A SOCIO-SCIENTIFIC CHOICE
this can be by
this can be by
this can be by
which to choose
which to choose
which to choose
consider
CHLORINE WATER
CHLORINE GAS
?
RISK OF USAGE
CHLORINE In solution
OR As a gas
an alternative is
advantage
disadvantage
Also consider
Investigate how to make
BLEACH
EASILY STORED IF COMPRESED
POISONOUS GAS; DANGEROUS IF LEAKED
Consider - Effectiveness, Ease of Use, Storage Cost
advantages
investigate how to make
In solution; Easy to handle
remedy for victims
Decided by
Bleach/Chlorine Gas
Expose to Fresh Air
disadvantages
Instability; Storage space needed; Dangerous if acidified
DISCUSSION
(Compare Advantages and Ddisadvantages)
explanation is by
can also be used for
Leading to
POSTER
1. Decolorant
(Indicator paper, coloured flowers)
2. Whitener
3. Household cleaner
THEORY
symbolically represented by
communication of uses by
explanation by
IONIC EQUATION
DECISION MAKING

THE SUGGESTED TEACHING APPROACH CAN FOLLOW ON FROM THIS REFORMED MAP

Leading to

* **Teaching using a wider range of educational competences.**

(in an intellectual, personal, and social sense). (Partnership for 21st Century Skills, 2009).

* **Teaching begins from the society context** (motivational - gives relevance).

(Holbrook 2004, Holbrook and Rannikmäe, 2010).

* **Student learning is constructive and inquiry-oriented** (Holbrook & Rannikmäe, 2014).

*The everyday life beginning makes the learning more interdisciplinary in interlinking conceptual chemistry with cross-cutting competences

(society relatedness and potentially career awareness). (Holbrook & Rannikmäe, 2014).

INTRODUCING
TRANDISCIPLINARY CHEMISTRY EDUCATION
AS WIDENING THE VISION
from
CHEMISTRY IN SOCIETY (separate entities)
and embracing
CHEMISTRY FOR/WITH SOCIETY (interrelated entities)

Reason

Greater relevance;

Greater societal purpose;

Greater student motivation towards learning in a society needs context

e.g. Integrated learning - STEM, STEAM, TCE.

Remembering a report developed by the International Commission on Education for the Twenty-First Century, chaired by Jacques Delors, in cooperation with UNESCO

The Delors Report strongly emphasized four pillars for education:

Learning to know,

Learning to do,

Learning to live together, and

Learning to be.

In this context, the transdisciplinary approach is seen as making an important contribution to the advent of this type of education.

TRANS-DISCIPLINARITY

Alfonso Montuori (2008) in his book saw –

"Transdisciplinarity is perhaps, above all, a new way of thinking about, and engaging in, inquiry."

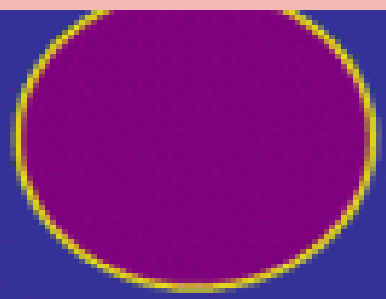
Chemistry Education through a transdisciplinary approach lends itself to a **'science for & within society' vision** as opposed to a **'science in society' perspective**, plus the establishment of an approach to raise cognition and awareness of a need to tackle **socio-scientific issues** which impact on the global society, together with the need for a **responsible citizenry**, plus enhancing related **employability skills.**

Transdisciplinarity in practice

1. Accepts that our ultimate intent is to ***strive towards resolutions pertaining to the world as a complex whole*** rather than solving problems pertaining to only a part of the world.
2. Focuses on ***new ways to illustrate the complexity of societal problems/issues*** and as analogical ways from the familiar to the unfamiliar.
3. Respects that, although knowledge from separate disciplines is an important first-step knowledge, there is a need to work collaboratively to ***unite the knowledge gained from interacting within societal margins.***
4. Acknowledges that ***simplifying reality so as to simplify our work is not helpful.*** We need to ***embrace the complexity of life*** and put in place permanent, complex structures and processes to work in intellectual outer-space.
5. Establishes ***workshops of transdisciplinary research*** comprising researchers from all disciplines and people outside academia eg from the arts, engineering, managers.
6. Recognises the need for ***consensus decision making that involve cooperation among the different components of society, including academia.***

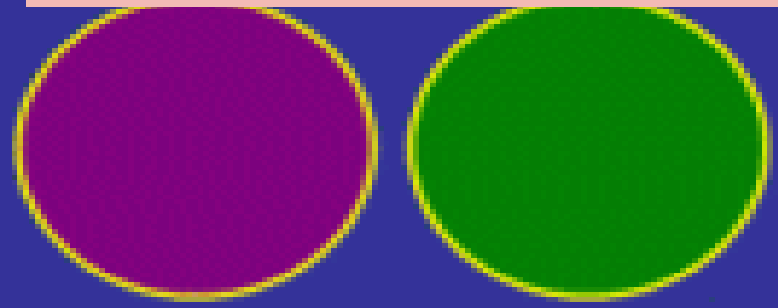
CONCEIVING DISCIPLINARY APPROACHES?

Driven by the Discipline



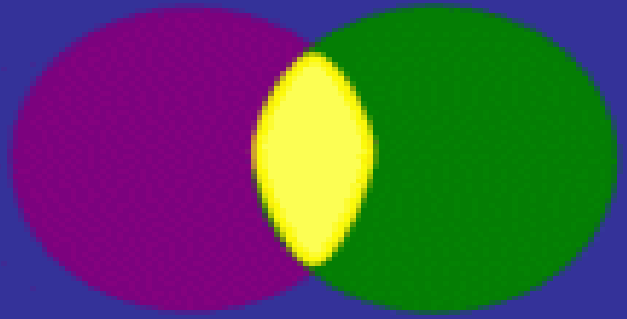
Disciplinary

Driven by Disciplines separately



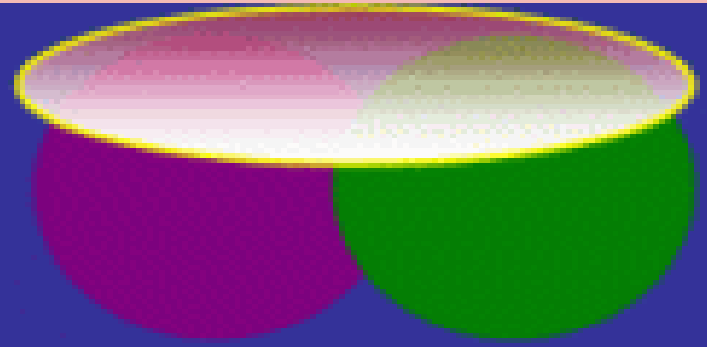
Multidisciplinary

Driven by Disciplines interlinking for Society needs,



Interdisciplinary

Driven by Societal needs, plus Career needs and Needs for Sustainability



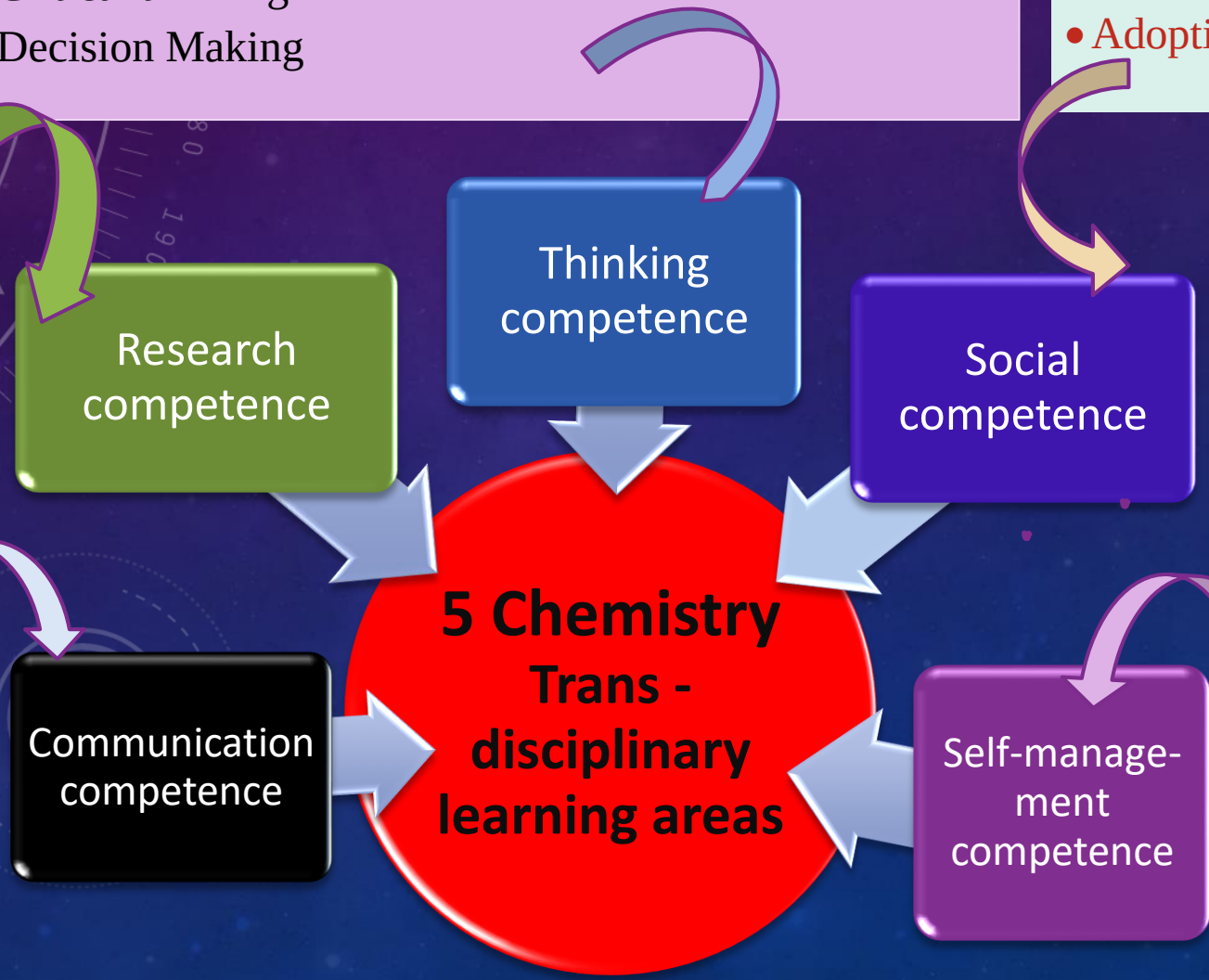
Transdisciplinary

- Problem solving
- Create questions
- Construct/modify
- Make observations
- Make research plans
- Collect data
- Organise data
- Interpret data
- Presentation skills

- Acquiring knowledge
- Comprehension/conceptualising
- Linking with previous knowledge
- Application to new situations
- Critical thinking
- Decision Making

. Analysing
. Synthesising
. Evaluating
. Metacognition

- Taking Responsible Actions
- Adopting Respectful Behaviour
- Cooperating and collaborating
- Justified decision-making
- Developing Leadership Skills
- Adopting Multiple Roles



- Listening
- Speaking
- Reading
- Writing
- Presenting (using ICT)
- Non-verbal communication

- Creativity & Innovation
- Planning skills
- Time management
- Safety awareness
- Understanding surroundings
- Taking care of oneself
- Making choices
- Controlling own behaviour

TRANS-DISCIPLINARITY WITHIN CHEMISTRY EDUCATION

The Trans-disciplinarity in Chemistry Education operates:

- Through action with respect to RELEVANT society-related, learning areas.

- Enhancing problem-solving, seeking justified solutions and promoting the use of imagination and creative thinking.

- And seeks to incorporate 'with and for' society-related decision-making, involving argumentation for societal acceptable resolutions and development (thus promoting sustainable societies).

It is driven by a CHEMISTRY 'WITHIN AND FOR' SOCIETY purpose, seeing the chemistry interrelating and addressing needs within a sustainable society. (EU Horizon 2020)

UNIVERSITY OF TARTU

THANK YOU