CPCE Health Conference 2022

The importance of environmental sustainability for healthy ageing and the incorporation of systems thinking in education for a sustainable environment

Parallel Session D5

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Major Sections (1)

Background

- The importance of environmental sustainability
- International perspectives on chemical wastes
- Effects of pollution on elderly health
- Research studies investigating sustainable chemistry and its development for achieving the Sustainable Development Goals (SDGs)
- Promoting sustainability through green chemistry

Role of education for a sustainable environment

- The importance of environmental sustainability

Major Sections (2)

Framework of chemical education for a sustainable environment

- Adoption and goals of systems thinking in chemical education
- Goals of systems thinking
- Richmond's Seven Systems Thinking Skills
- Systems Thinking Hierarchical Model (STH Model)

Systems thinking, public health and education

Assessment Tools: SOCME Applications

Background

Importance of a sustainable environment for healthy ageing

- Extensive use of hazardous chemicals leading to possible chemical pollution
- Higher susceptibility of elderly people to the detrimental effects of chemical pollution
- Effects can be lethal even for a short-term exposure to air pollutants, especially considering conditions of comorbidity and pathological ageing

Simoni, M., Baldacci, S., Maio, S., Cerrai, S., Sarno, G., & Viegi, G. (2015). Adverse effects of outdoor pollution in the elderly. *Journal of thoracic disease*, 7(1), 34.

Bentayeb, M., Simoni, M., Baiz, N., Norback, D., Baldacci, S., Maio, S., ... & Geriatric Study in Europe on Health Effects of Air Quality in Nursing Homes (GERIE) Group. (2012). Adverse respiratory effects of outdoor air pollution in the elderly. The international journal of tuberculosis and lung disease, 16(9), 1149-1161.

Background

Sustainable Development Goal 3:

Ensure healthy lives and promote well-being for all at all ages

- Target 3.9
- "*By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination*"

Goal 3 | Department of Economic and Social Affairs (un.org)
https://sdgs.un.org/goals/goal3

Fong, B. Y., & Law, V. T. (2022). Sustainable Development Goal 3: Health and Well-being of Ageing in Hong Kong.

Background

Hazardous chemicals, international perspectives from developing and developed countries

- Developing countries, focus of public health attention is on urgent issues including infectious diseases, infant mortality, etc.
- Concerns to hazardous chemical wastes increase when a country develops more economic resources
- The situation is also alarming even for a country with little industry generating the hazardous chemical wastes, chemical waste importation for recycling or disposal also poses health concerns or hazards

Orloff, K., & Falk, H. (2003). An international perspective on hazardous waste practices. International Journal of Hygiene and Environmental Health, 206(4-5), 291-302.

Background

Examples of studies regarding the effects of pollution on elderly health

- Association with increased respiratory morbidity among the elderly population
- Significant effects on elderly mental health
- Positive association between short-term exposure to air pollutants and sleep disorder

Bentayeb, M., Simoni, M., Baiz, N., Norback, D., Baldacci, S., Maio, S., ... & Geriatric Study in Europe on Health Effects of Air Quality in Nursing Homes (GERIE) Group. (2012). Adverse respiratory effects of outdoor air pollution in the elderly. The international journal of tuberculosis and lung disease, 16(9), 1149-1161.

Tian, T., Chen, Y., Zhu, J., & Liu, P. (2015). Effect of Air Pollution and Rural-Urban Difference on Mental Health of the Elderly in China. Iranian journal of public health, 44(8), 1084–1094.

Tang, M., Li, D., Liew, Z., Wei, F., Wang, J., Jin, M., ... & Ritz, B. (2020). The association of short-term effects of air pollution and sleep disorders among elderly residents in China. Science of The Total Environment, 708, 134846.

Background

Promoting sustainability through green chemistry

- Heavy use of solvents in chemical industry – increasing organic pollution
- Increasing awareness of the impact of solvents on health and climate change
- Growing interest in research of sustainable solvents
- More studies regarding catalysis, processes, resource management, and environmental impact in the context of sustainable development framework

Kirchhoff, M. M. (2005). Promoting sustainability through green chemistry. Resources, conservation and recycling, 44(3), 237-243.

Clarke, C. J., Tu, W. C., Levers, O., Brohl, A., & Hallett, J. P. (2018). Green and sustainable solvents in chemical processes. *Chemical Reviews*, *118*(2), 747-800.

Marion, P., Bernela, B., Piccirilli, A., Estrine, B., Patouillard, N., Guilbot, J., & Jérôme, F. (2017). Sustainable chemistry: how to produce better and more from less?. *Green Chemistry*, *19*(21), 4973-4989.

Role of education for a sustainable environment

Only advance in science research is not enough…

Science education is important, and chemistry in specific, should educate citizens and realization of the need for environmental sustainability and social responsibility in chemical practice.

Use of hazardous chemicals can lead to serious threats to human health and the environment. Various reports have advocated the importance of reorienting education with elements of green and sustainable chemistry for a sustainable future.

Anastas, P. T., & Zimmerman, J. B. (2018). The United Nations sustainability goals: How can sustainable chemistry contribute? *Current Opinion in Green and Sustainable Chemistry, 13,* 150-153.

Aubrecht, K. B., Bourgeois, M., Brush, E. J., MacKellar, J., & Wissinger, J. E. (2019). Integrating Green Chemistry in the Curriculum: Building Student Skills in Systems Thinking, Safety, and Sustainability. *Journal of Chemical Education*, *96*(12), 2872-2880

Holme, T. A., & Hutchison, J. E. (2018). A central learning outcome for the central science. *Journal of Chemical Education, 95*(4), 499-501.

Framework of chemical education for a sustainable environment

Adoption of systems thinking in chemical education

Chemistry, being a central science, has important connections across disciplines.

A framework based on systems thinking is adopted. Systems thinking focuses on the interrelationships between concepts both within and between disciplines. A complete understanding is advocated.

Complementary to the reductionist approach, commonly adopted in science research.

Systems thinking is proposed for higher-order thinking skills and critical thinking.

York, S., Lavi, R., Dori, Y. J., & Orgill, M. (2019). Applications of systems thinking in STEM education. *Journal of Chemical Education*, *96*(12), 2742-2751.

Mathews, L. G., Jones, A., Szostak, R., & Repko, A. (2008). Using systems thinking to improve interdisciplinary learning outcomes: Reflections on a pilot study in land economics. *Issues in Interdisciplinary Studies*.

Framework of chemical education for a sustainable environment

Goals of systems thinking in chemical education

Educate future global citizens, chemists or practitioners in chemical industry with a systems thinking perspective.

More sustainable practices of production and consumption.

Holistic and systematic thinking of chemistry leading to maximizing resource efficiency and minimizing chemical hazards and pollution.

Education to inform evidence-based decisions regarding science-related policy.

Target application: students in general-education chemistry course

Tools: systems-oriented concept map extension (SOCME) diagrams

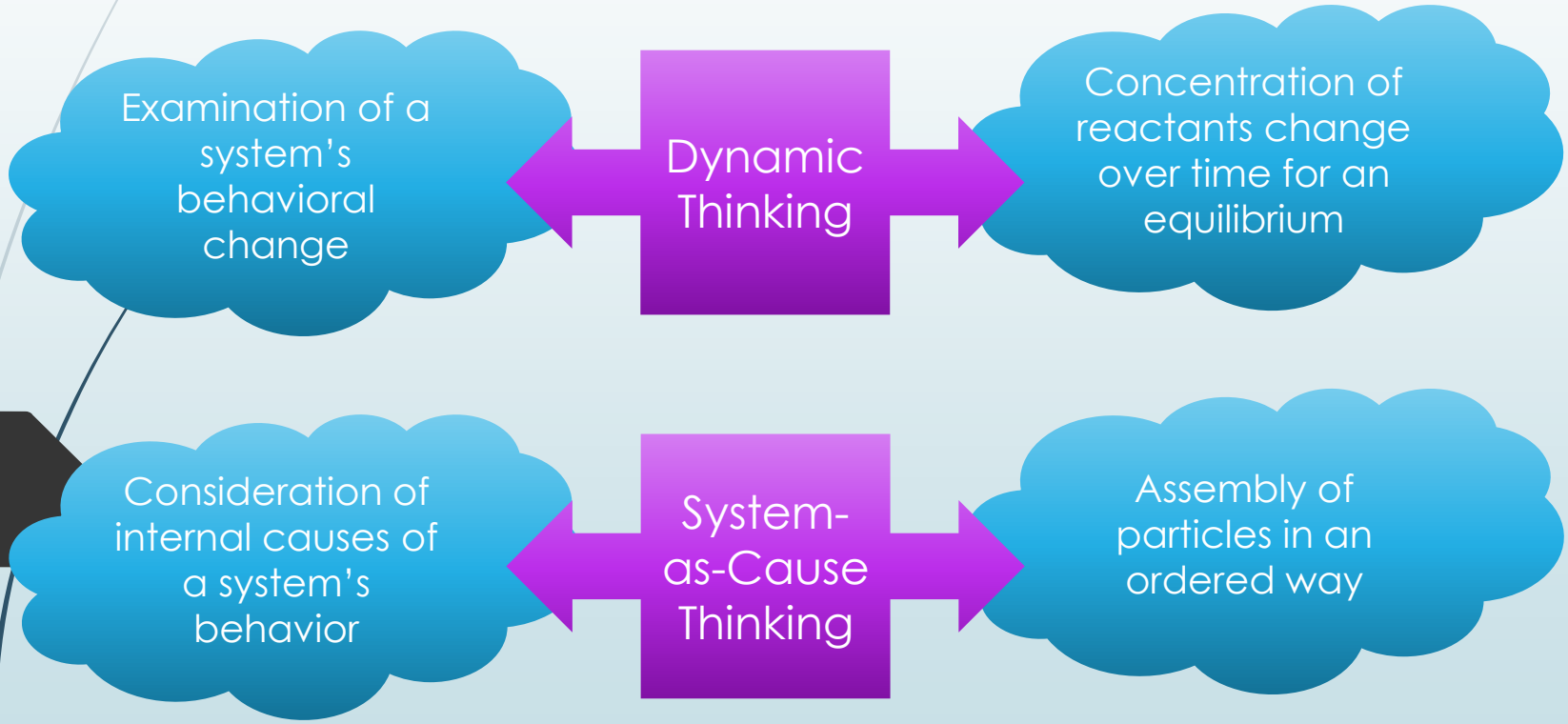
Framework of chemical education for a sustainable environment

Richmond's Seven Systems Thinking Skills

Richmond, B. (1997). The "thinking" in systems thinking: how can we make it easier to master. *The Systems Thinker*, *8*(2), 1-5.

Framework of chemical education for a sustainable environment

Richmond's Systems Thinking Skills and Examples of Applications in Chemistry

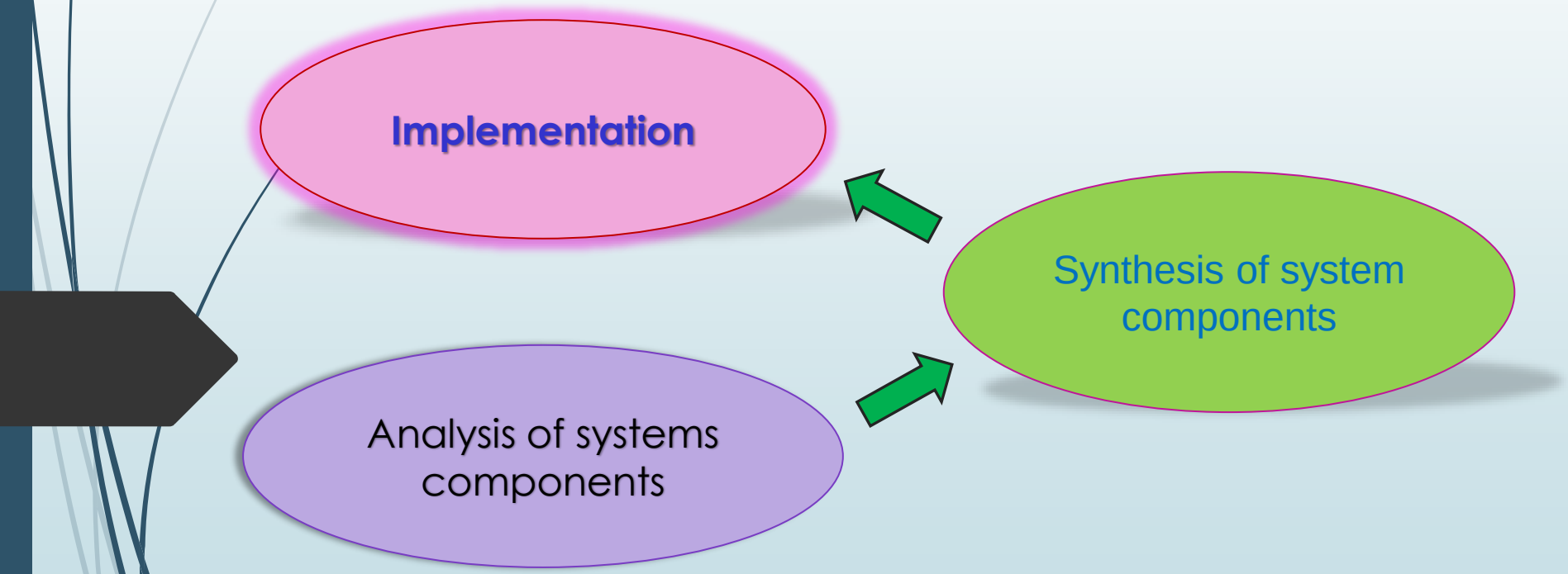


However, there are limitations with regards to the context of applications in chemical education…

Framework of chemical education for a sustainable environment

Systems Thinking Hierarchical Model (STH Model)

The three indicative levels (from lower-level to higher-level):



Ben-Zvi-Assaraf, O., & Orion, N. (2010). Four case studies, six years later: Developing system thinking skills in junior high school and sustaining them over time. Journal of Research in Science Teaching, 47(10), 1253-1280.

Framework of chemical education for a sustainable environment

Systems Thinking Hierarchical Model (STH Model)

Examination of systems thinking abilities of junior high school students, based on the learning of water cycles.
Eight definite systems thinking skills grouped under the three levels in STH Model.

Analysis of systems components

The ability to identify the components of a system and processes within the system

Assaraf, O. B. Z., & Orion, N. (2005). Development of system thinking skills in the context of earth system education. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *42*(5), 518-560.

Ben-Zvi-Assaraf, O., & Orion, N. (2010). Four case studies, six years later: Developing system thinking skills in junior high school and sustaining them over time. Journal of Research in Science Teaching, 47(10), 1253-1280.

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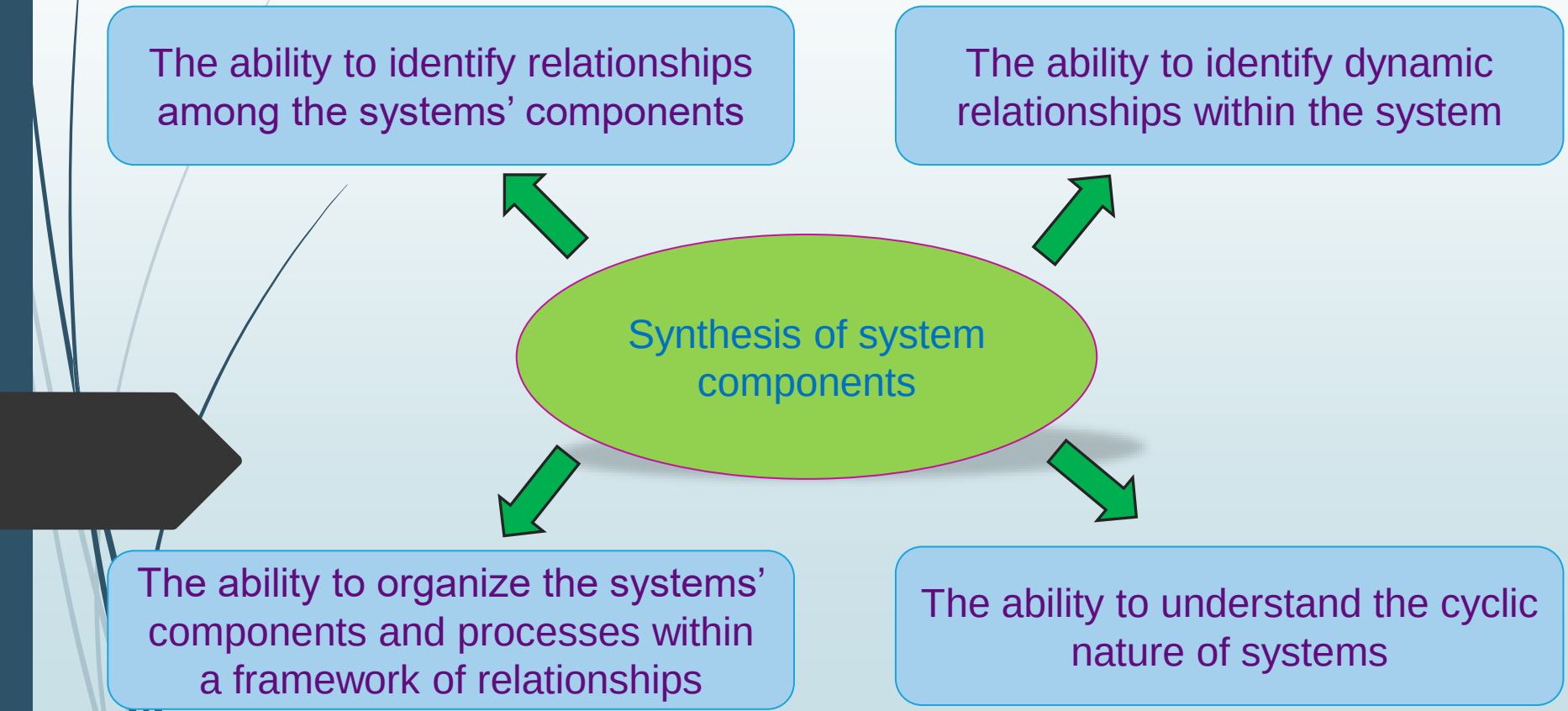
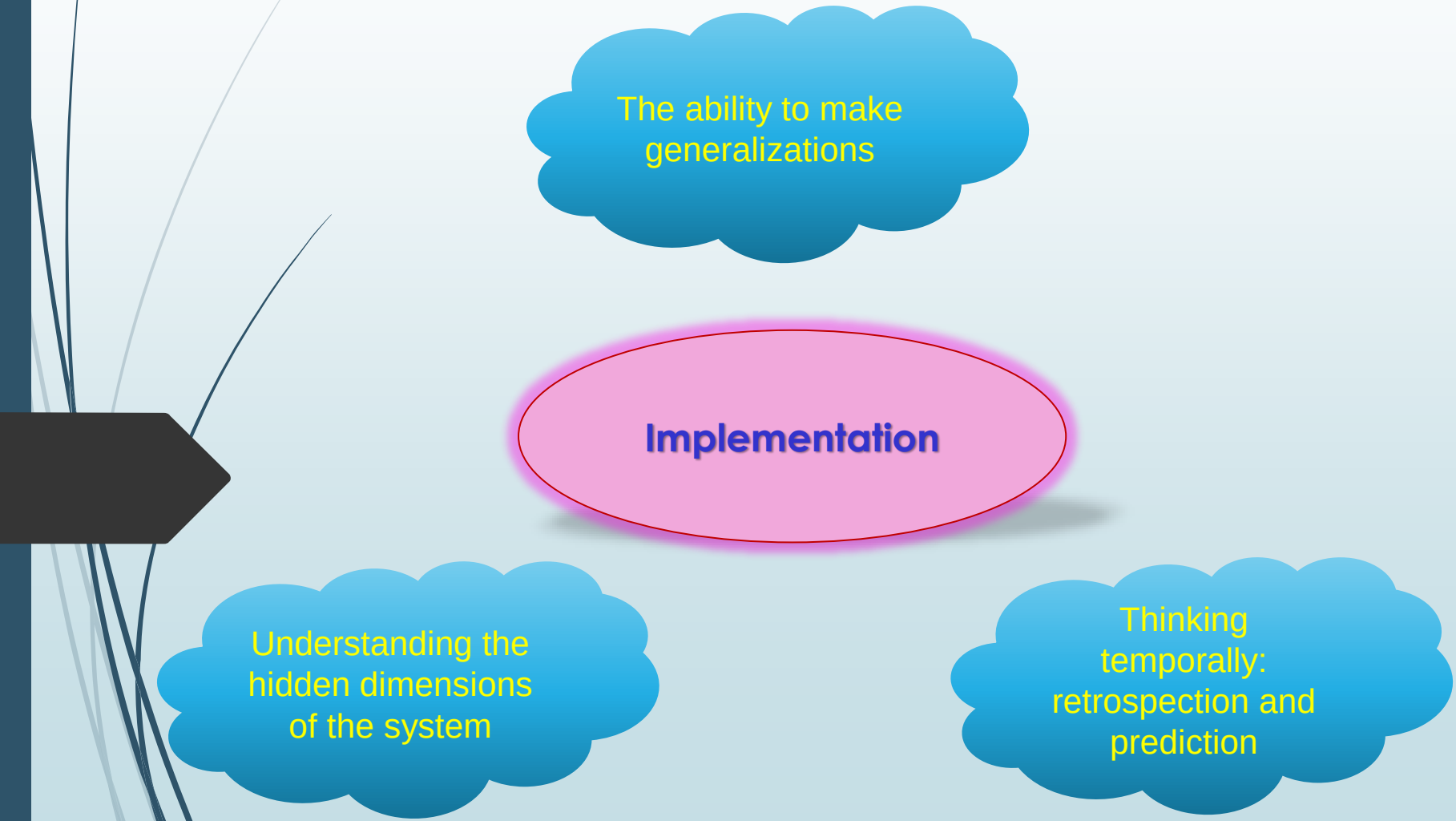
Systems Thinking Hierarchical Model (STH Model)



Framework of chemical education for a sustainable environment

Systems Thinking Hierarchical Model (STH Model)



Systems thinking, public health and education

- When addressing global challenges such as pollution, sustainability and climate change, chemists need to know the implications of their decisions and actions on various systems, at local, national and international scales, including the political, social, economic, and environmental systems.

- Therefore, integration of systems thinking in chemical education requires a clear-cut and specific consideration of the effects of human choices and actions on both chemical systems and on the larger systems

Mahaffy, P. G., Matlin, S. A., Holme, T. A., & MacKellar, J. (2019). Systems thinking for education about the molecular basis of sustainability. *Nature Sustainability, 2*(5), 362-370.

Assessment Tools - SOCME

- **Graphical Tools for Conceptualizing Systems Thinking in Chemistry Education** - systems-oriented concept map extension (SOCME) diagrams

- Examples

✓ Material circularity through minimising waste, examples include aluminium, plastics and textiles

✓ SOCME illustration of the biogeochemical flow of carbon dioxide

Aubrecht, K. B., Dori, Y. J., Holme, T. A., Lavi, R., Matlin, S. A., Orgill, M., & Skaza-Acosta, H. (2019). Graphical tools for conceptualizing systems thinking in chemistry education. Journal of Chemical Education, 96(12), 2888-2900.

Matlin, S. A., Mehta, G., Hopf, H., Krief, A., Keßler, L., & Kümmerer, K. (2020). Material circularity and the role of the chemical sciences as a key enabler of a sustainable post-trash age. *Sustainable Chemistry and Pharmacy*, *17*, 100312.

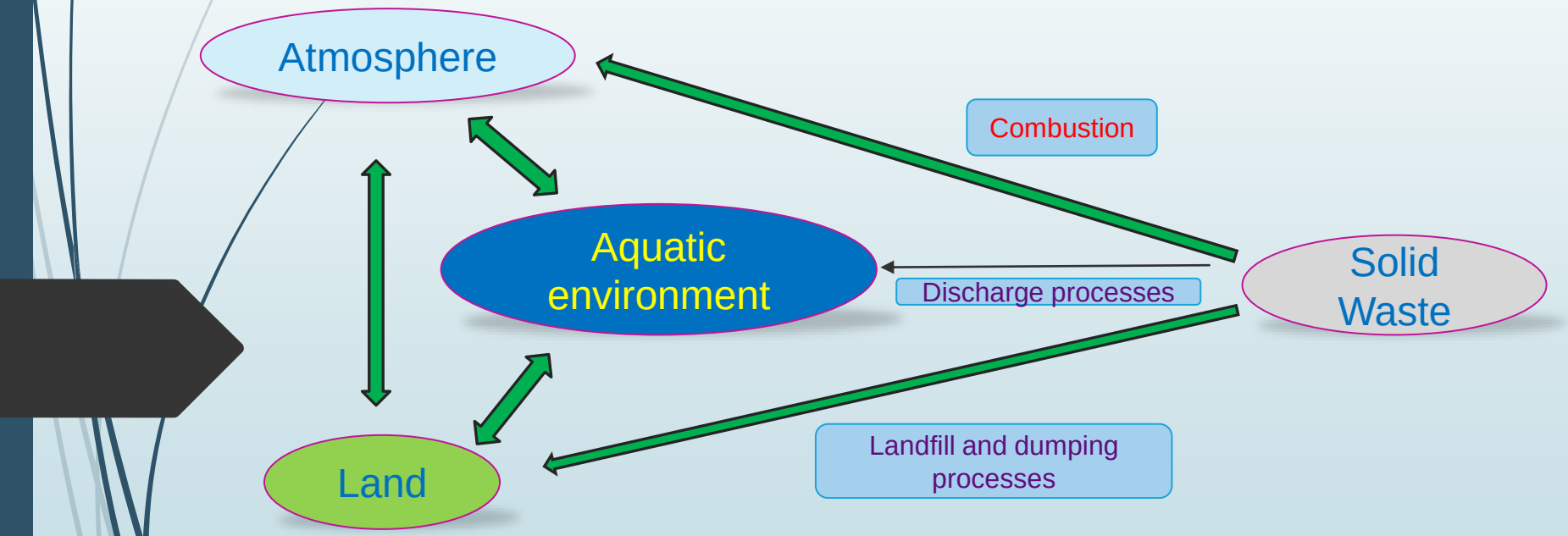
Matlin, S. A. Introducing the SOCME tool for systems thinking in chemistry.

SOCME Applications

Material circularity through minimising waste, examples include aluminium, plastics and textiles

Identification of interconnections between
Solid, liquid and gas forms of wastes, sub-systems involved, chemical and biological processes.

Modified and simplified diagram for illustration example:



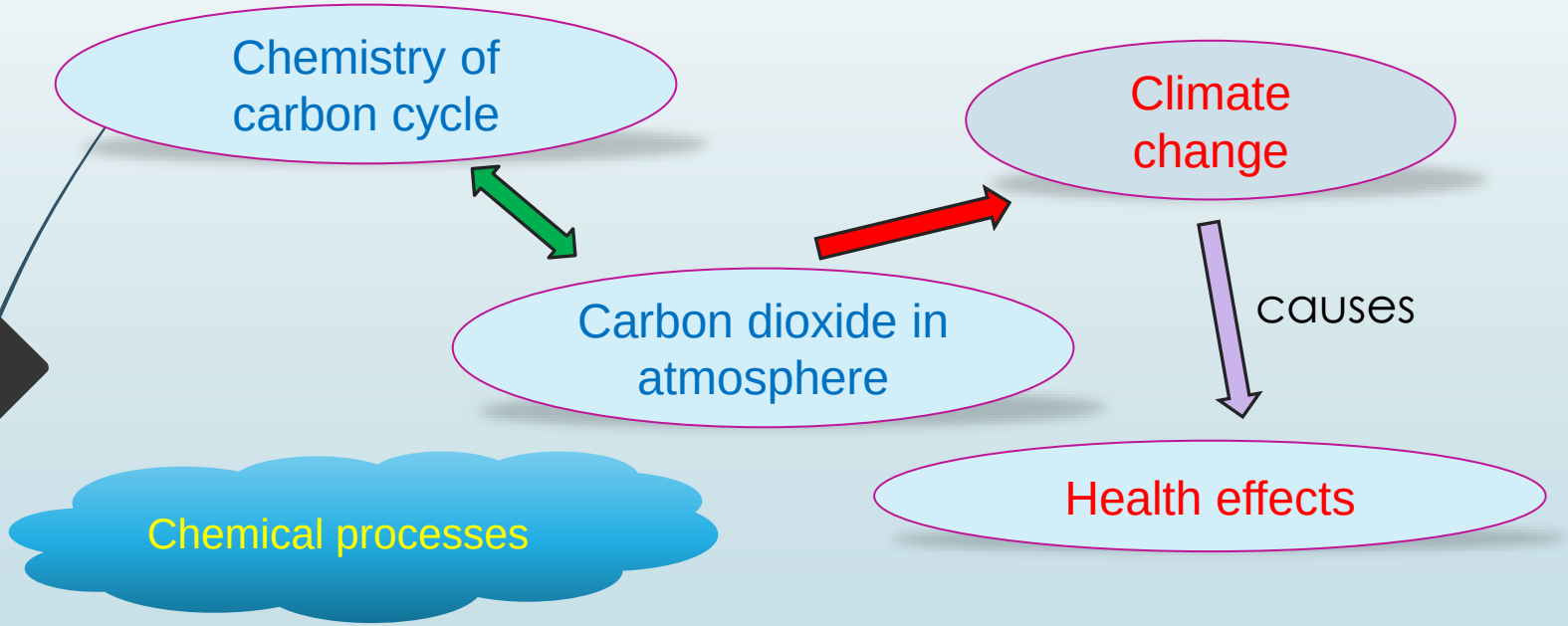
Matlin, S. A., Mehta, G., Hopf, H., Krief, A., Keßler, L., & Kümmerer, K. (2020). Material circularity and the role of the chemical sciences as a key enabler of a sustainable post-trash age. *Sustainable Chemistry and Pharmacy*, *17*, 100312.

SOCME Applications

SOCME for biogeochemical flow of carbon dioxide

Use of Concept Maps for identification of key areas and interconnections between different systems

Use of SOCME for illustration of identified areas regarding carbon dioxide



Matlin, S. A. Introducing the SOCME tool for systems thinking in chemistry.

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Q & A

Thank you!