

Threshold Concepts in Chemistry

SciMaG – Work Package 2

Threshold concepts are conceptual gateways that can open a previously inaccessible way of thinking about a subject and enable further learning. They are commonly described as potentially transformative, irreversible, integrative, bounded, and troublesome. Not every difficult or important concept is necessarily a threshold concept; the key issue is whether understanding it changes the learner's way of seeing and using disciplinary knowledge.

Identified Threshold Concepts

Periodic System of Elements as a Threshold Concept

The periodic table organizes elements according to atomic structure and recurring patterns in their properties.

Threshold characteristic	Explanation
Troublesome	Learners may memorize isolated facts without understanding periodicity, electronic structure, or trends.
Transformative	The table becomes a predictive model rather than a list to memorize.
Integrative	It connects atomic structure, reactivity, bonding, periodic trends, and chemical properties.
Bounded	Its meaning is grounded in the organization of elements and periodic relationships.
Irreversible	It becomes a durable tool for predicting and explaining chemical behaviour.

Related SciMaG learning activity: S11 and G11

Nomenclature as a Threshold Concept

Chemical nomenclature provides the systematic language for naming and identifying substances.

Threshold characteristic	Explanation
Troublesome	Learners must coordinate rules, formulas, compound classes, and variable oxidation states.
Transformative	Names become meaningful representations of chemical identity rather than arbitrary labels.

Integrative	It supports chemical formulas, reactions, stoichiometry, structure, and communication.
Bounded	Systematic naming conventions and chemical-class-bound nomenclature.
Irreversible	Repeated use makes the naming system a durable part of disciplinary language.

Related SciMaG learning activity: S13 and G12

Biomolecules as a Threshold Concept

Biomolecules connect organic chemistry with biological structure and function.

Threshold characteristic	Explanation
Troublesome	Learners must relate molecular structures to functions that are often invisible and dynamic.
Transformative	Biological processes become interpretable through molecular structure and function.
Integrative	It integrates chemistry, cell biology, metabolism, genetics, and molecular biology.
Bounded	The concept is bounded by classes of biologically relevant molecules and their roles.
Irreversible	Structure-function reasoning becomes a durable framework for later biochemistry.

Related SciMaG learning activity: S14 and G11

Enthalpy as a Threshold Concept

Enthalpy provides a quantitative framework for analysing heat changes in chemical and physical processes.

Threshold characteristic	Explanation
Troublesome	It is abstract and requires distinguishing temperature, heat transfer, internal energy, and enthalpy.
Transformative	Learners can interpret reactions in terms of energy change rather than only observable temperature effects.
Integrative	It connects thermochemistry, reaction energetics, Hess's law, and thermodynamics.

Bounded	Its meaning depends on thermodynamic definitions and system conditions.
Irreversible	It becomes a reusable framework for analysing energetic changes.

Related SciMaG learning activity: S15 and G10

Chemical Equations and Reactions as a Threshold Concept

Chemical equations represent substances transforming through chemical reactions.

Threshold characteristic	Explanation
Troublesome	Learners must connect observable changes, molecular models, formulas, coefficients, and conservation of atoms.
Transformative	Chemical change becomes interpretable as rearrangement of particles rather than only an observable event.
Integrative	It integrates stoichiometry, reaction types, kinetics, thermodynamics, and molecular structure.
Bounded	The concept is bounded by chemical reaction models and conservation principles.
Irreversible	Symbolic representation of reactions becomes a stable foundation for further chemistry learning.

Related SciMaG learning activity: S13 and G12

References

Meyer, J. H. F., & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. Higher Education, 49(3), 373–388. <https://doi.org/10.1007/s10734-004-6779-5>