

Threshold Concepts in Physics

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

Matter as a Threshold Concept

Matter provides a basis for understanding physical properties, states, particles, and interactions.

Threshold characteristic	Explanation
Troublesome	Learners must connect observable properties with invisible particle-level explanations and often hold competing mental models.
Transformative	The particle model changes how learners explain states of matter and physical change.
Integrative	It connects properties of matter, states, energy, interactions, and microscopic models.
Bounded	The concept is bounded by scientific models used to explain substances and their behaviour.
Irreversible	A coherent particle-based understanding becomes a durable framework for interpreting later phenomena.

Related SciMaG learning activity: Matter Is All Around Us – S51

Physical Field as a Threshold Concept

A physical field provides a model for interactions that do not require direct contact.

Threshold characteristic	Explanation
Troublesome	Fields are invisible and abstract; learners struggle with how a field can exist and influence objects at a distance.
Transformative	The concept shifts reasoning from contact forces to spatially distributed interactions.

Integrative	It connects force, energy, gravity, electricity, magnetism, and wave phenomena.
Bounded	Field concepts have specific meanings within physics and differ from everyday uses of 'field'.
Irreversible	Field-based reasoning becomes a durable framework for interpreting interactions at a distance.

Equilibrium as a Threshold Concept

Equilibrium provides a framework for understanding when interacting effects balance.

Threshold characteristic	Explanation
Troublesome	Learners may equate equilibrium with 'nothing is happening' and struggle with multiple forces or dynamic equilibrium.
Transformative	It changes how learners analyse systems by focusing on balances among interacting quantities.
Integrative	It connects force, moments, stability, mechanics, and dynamics.
Bounded	The concept is bounded by defined equilibrium conditions within a physical system.
Irreversible	Equilibrium becomes a reusable analytical principle across mechanical situations.

Related SciMaG learning activity: Balance Challenge – S5; Who Made the Mistake? – S6

Laws of Conservation as a Threshold Concept

Conservation laws provide a unifying way to analyse physical processes through quantities that remain constant within defined systems.

Threshold characteristic	Explanation
Troublesome	Learners find it difficult to reconcile visible change with conservation and to identify system boundaries.
Transformative	Conservation reasoning shifts attention from isolated events to system-level accounting.
Integrative	It connects mechanics, thermodynamics, electricity, and other areas of physics.

Bounded	Conservation statements depend on the physical quantity and defined system and conditions.
Irreversible	The conservation framework becomes a durable strategy for analysing unfamiliar situations.

Related SciMaG learning activity: Team Competition – S3; Find and Fix – S4

Energy as a Threshold Concept

Energy is a unifying concept for explaining transfer and transformation across physical systems.

Threshold characteristic	Explanation
Troublesome	Energy is not directly observable, occurs in multiple forms, and is often confused with fuel, force, or activity.
Transformative	Learners move from thinking of energy as an object or substance to reasoning about transfer, transformation, and conservation.
Integrative	It links mechanics, thermal phenomena, electricity, chemistry, and biological systems.
Bounded	Energy is a defined physical quantity whose use depends on the system and context.
Irreversible	A conceptual understanding of energy provides a stable framework for interpreting many new phenomena.

Related SciMaG learning activity: Team Competition – S3; Find and Fix – S4

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>