Co-funded by the European Union

Threshold Concepts in Computer Science

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

Logical Conditions as a Threshold Concept

Logical conditions introduce decision-making and conditional control of program flow.

Threshold characteristic	Explanation
Troublesome	Learners must reason about truth values, combined conditions, and their effect on execution.
Transformative	Programming becomes a means of modelling decisions rather than only executing fixed sequences.
Integrative	It connects algorithms, data, control flow, and problem-solving.
Bounded	Conditional control marks a boundary between linear and branching program structures.
Irreversible	Conditional reasoning becomes a reusable programming pattern.

Related SciMaG learning activity: [ai] explore! in Scratch; Logo 1; Logo 2

Iteration (Loops) as a Threshold Concept

Iteration enables repeated execution and scalable algorithmic solutions.

Threshold characteristic	Explanation
Troublesome	Learners must understand repetition, control flow, termination, and repetition without copying code.
Transformative	Learners move from repeated instructions to compact, general algorithms.
Integrative	It connects algorithms, control flow, efficiency, data processing, and automation.

Bounded	The concept is bounded by repetition structures and their control conditions.
Irreversible	Loops become a standard strategy for constructing complex programs.

Related SciMaG learning activity: [ai] explore! in Scratch; Logo 1; Logo 2

Functions and Procedures as a Threshold Concept

Functions and procedures introduce decomposition, modularity, abstraction, and code reuse.

Threshold characteristic	Explanation
Troublesome	Learners must understand calls, parameters, scope, and the difference between defining and executing a procedure.
Transformative	Program structure changes from monolithic code to reusable conceptual units.
Integrative	It integrates abstraction, modularity, readability, reuse, and algorithmic design.
Bounded	It is bounded by mechanisms for encapsulating and invoking reusable program units.
Irreversible	Modular decomposition becomes a durable programming practice.

Related SciMaG learning activity: Logo 1; Logo 2

Variables as a Threshold Concept

Variables provide a mechanism for representing and manipulating changing data.

Threshold characteristic	Explanation
Troublesome	Learners may confuse a variable name with its current value and struggle with changing state, types, and scope.
Transformative	Programming shifts toward representing generalised solutions and changing program state.
Integrative	Variables connect data representation, algorithms, functions, state, and program behaviour.
Bounded	The concept is bounded by rules governing values, types, scope, and state.
Irreversible	Variable-based reasoning becomes a durable foundation for programming.

Related SciMaG learning activity: [ai] explore! in Scratch; Logo 1; Logo 2

Object-Oriented Programming as a Threshold Concept

Object-oriented programming introduces a paradigm for modelling entities, state, behaviour, and relationships.

Threshold characteristic	Explanation
Troublesome	Learners must coordinate abstractions such as classes, objects, encapsulation, inheritance, and polymorphism.
Transformative	Program design shifts from procedural sequences toward models of interacting entities and responsibilities.
Integrative	It integrates abstraction, modularity, reuse, extensibility, and software design.
Bounded	Its concepts are bounded by the object-oriented paradigm and its abstractions.
Irreversible	For learners who internalise the paradigm, object-oriented modelling becomes a durable way of structuring larger programs.

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