ELEMENTAL

Overview

Elemental is a serious educational board game designed to support the learning of periodic trends and element classification at GCSE and early A-level chemistry. The game responds to a common issue in chemistry education: while students may memorise periodic facts, they often struggle to apply trend knowledge through reasoning and comparison. Rather than functioning as a quiz or recall exercise, Elemental frames chemical knowledge within a deduction-based game that encourages discussion, hypothesis testing, and justification through play.

A serious game is defined by a primary purpose beyond entertainment, with the game acting as a framework that enables a learning experience rather than constituting the experience itself (Abt, 1970). Elemental was therefore designed not as a test of chemical facts, but as an interactive system that prompts players to reason about periodic trends through structured questioning and collaborative decision-making.

In doing so, the game also reinforces that the periodic table is not a random arrangement of elements, but a structured system in which position reflects underlying atomic properties. By requiring players to compare and reason across the table, Elemental builds a conceptual understanding of periodic structure that supports progression to more advanced chemistry topics.

Gameplay

Elemental is played in two teams: one player serves as the card holder, and the remaining players act as guessers. At the start of each round, the card holder draws an element card, which remains hidden from the guessing team. Guessers must identify the element within a fixed time limit by asking yes/no questions related to element classification and periodic trends.

Questions may concern group or period position, metal or non-metal classification, or comparative trends such as atomic radius, reactivity, and ionisation energy. Only one location question (group or period) may be asked per element; if the team asks both, that element is forfeited and scores 0 points. Each trend-based question earns the team a trend token, strengthening the value of using trends rather than guessing. At any point before the time runs out, the team may choose to guess by pointing to an element on the periodic table and verbally justifying their choice.

If the guess is correct, the team scores points equal to the card's difficulty value plus any trend tokens earned, and moves their playing piece accordingly along the track. If incorrect, no points are awarded, and they move on to the next card. The first team to reach the end of the track wins.

Learning Objectives

Elemental was designed with explicit learning objectives aligned to the chemistry curriculum and informed by learning theory introduced in this module. By playing the game, learners are expected to:

- **Recall** factual chemical knowledge (group numbers, metals vs non-metals, basic periodic structure).
- **Apply** knowledge of periodic trends (reactivity, atomic radius, ionisation energy) to narrow down unknown elements through comparison.
- **Analyse** incomplete information by selecting high-value questions and interpreting responses.
- **Evaluate** when sufficient evidence has been gathered to justify a confident guess under time pressure.
- **Communicate** scientific reasoning clearly and collaborate well within a team to solve problems

Bloom's Taxonomy delivers a framework for designing learning experiences that move beyond simple recall towards higher-order thinking (Bloom et al., 1956). Elemental embeds multiple levels of Bloom's Taxonomy within its mechanics. Bloom's Taxonomy is useful for describing how Elemental moves beyond recall. Players remember and understand key facts (group/classification), apply and analyse trend knowledge using comparative questioning, and evaluate risk when deciding whether to commit to a guess under time pressure.

Rather than forcing all cognitive levels into a single mechanic, opportunities for creating are introduced through an optional post-game extension. After gameplay, teams may combine correctly identified elements to form a chemically valid compound and justify the bonding involved. This allows learners to synthesise knowledge without disrupting the core game rhythm, meaning purposeful alignment between learning objectives and mechanics.

Design of the Game

It is important to understand the audience and purpose when making design decisions, particularly regarding visual communication and usability. Therefore, designing Elemental for a younger audience meant prioritising engagement, clarity, and playfulness. To prevent the game from feeling blatantly instructional, educational content is subtly integrated into the mechanics and aesthetics, allowing learning to occur implicitly through play.

For example, the text on the board was intentionally minimised to reduce cognitive demand, particularly given the periodic table's inherent visual complexity. Atomic masses were removed from the periodic table, as they were not relevant to the target age range and contributed unnecessary visual clutter. Aside from the game title and "start" and "finish" markers, information is communicated almost entirely through imagery.

The primary communication tool for this game was the visual theming. The electron-shell-shaped path around the periodic table immediately signals the chemistry theme and supports the importance of electron arrangement when distinguishing elements. The background illustration features subtle, hand-drawn chemistry motifs that offer depth and thematic reinforcement without distracting from gameplay. These elements are deliberately low-contrast and secondary to ensure that the playable area remains visually dominant.

Colour was used both aesthetically and functionally. Bold yet somewhat muted tones were selected to appeal to younger players without overstimulating. The periodic table follows standard GCSE colour conventions to support familiarity and transfer of learning. Later iterations introduced a darker background to improve contrast and visual hierarchy, helping the central board stand out more clearly. The design was also tested in greyscale to ensure that key information stayed accessible without relying solely on colour.

These visual and aesthetic decisions are not decorative but pedagogical, supporting faster pattern recognition, reducing extraneous mental effort, and helping players focus on relational properties between elements instead of isolated facts (Sweller, 1988).

Randomness in Elemental is limited to input randomness through drawing element cards, which varies the problem presented each round before any decisions are made (Slack, 2022). Crucially, randomness never determines movement or scoring outcomes: progress is earned through correct identification and justified reasoning. This preserves player agency while maintaining replayability and avoiding luck-dominant resolution.

Point values were assigned in advance based on difficulty (Levels 1–3). Elements that are highly distinctive at GCSE level (for example, common groups with clear classification cues) were weighted lower, while elements that are less distinctive or demand finer trend-based elimination were weighted higher. Because the movement track contains 32 spaces, most cards were set at Level 1–2 to maintain pacing and prevent single draws from controlling the outcome, while still rewarding deeper reasoning when harder elements appear.

Prototyping

Elemental was developed through an iterative design process, in line with the principles introduced in Week 6 on design thinking (Brown, 2008). Early prototypes revealed that, missing explicit incentives, players could succeed through broad classification questions without meaningfully engaging with periodic trends. While the deduction structure remained functional, the chemistry component risked becoming superficial, as correct guesses could be achieved without applying trend knowledge.

In response, the trend token mechanic was introduced to explicitly reward the use of trend-based reasoning. By granting additional points for questions involving reactivity, atomic radius, or ionisation energy, the game shifted from a general guessing exercise

to one that actively privileged chemical understanding. This change ensured that successful play was tightly coupled to disciplinary knowledge, strengthening the game's identity as a serious educational tool rather than a generic deduction game.

Playtesting

During self-playtesting, a significant design flaw emerged: teams could reliably identify any element by asking only two questions, its group and its period, without engaging with periodic trends at all. While this made the game solvable, it undermined its educational purpose by allowing players to bypass chemical reasoning.

To address this, the rules were refined to allow only one location-based question per element, forcing players to rely on trend comparisons and classification instead. In later iterations, yes/no questioning was enforced to further restrict communication and prevent descriptive shortcuts. These changes closed the exploit and ensured that successful play required application of periodic knowledge rather than procedural elimination. This iterative refinement reflects a deliberate testing-and-adjustment process concentrated on aligning gameplay with learning objectives.

Results/What Next

Elemental shows that periodic trend reasoning can be embedded meaningfully within a timed deduction format without relying on chance-based progression or rote memorisation. The game balances engagement and educational purpose without relying on chance-based progression or rote recall. The element cards also create opportunities for extension tasks, including the optional post-game compound activity, allowing the game to support progression beyond core trend reasoning. Future iterations could explore adaptations for different age ranges, such as a simplified KS3 version or an advanced A-level variant with additional trends.

Further development could also include a classroom facilitation guide or digital companion to support remote or hybrid learning environments. These extensions would allow the game to be integrated more flexibly into teaching contexts while maintaining its core design philosophy.

References

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