Title: ACTIVE LEARNING SYSTEM, METHOD, BOARD GAME AND CARD GAMES, GAME BOARD AND PLAYING CARDS FOR USE THEREWITH

Abstract: An active learning system comprises a plurality of learning modules whose contents together make up a predetermined corpus of knowledge to be learned by the participant(s), a corresponding plurality of sets of questions/facts relating to the learning modules, respectively, and rules prescribing a sequence of events constituting a learning session having a learning session start and a learning session finish. The events may comprise selecting at least some of said learning modules individually and successively, selecting one of the set of related questions/facts for the participant to answer, and recording progress of the participant from a learning session start towards a learning session finish according to whether or not the participant answers the selected questions correctly. The progress chart preferably is appropriate to the subject to be learned; for example the Periodic Table of Elements for chemistry, DNA sequences for molecular biology, Canada's Food Plan for nutrition, and so on. An active learning educational card game comprises a set of cards and rules for playing at least one card game using them. Each of the cards represents a respective one of the chemical elements listed in the Periodic Table of Chemical Elements and carries information about that chemical element. The rules prescribe for cards to be distributed to the players who, in their turns in a particular round of the game, attempt to use the cards to form chemical compounds, points being scored according the nature of the cards used or the nature of the compound formed, or both. Players may substitute cards from the same column, or within a defined group of individual elements or with cards from well-defined groups satisfying some specific criteria.
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ACTIVE LEARNING SYSTEM, METHOD, BOARD GAME AND CARD GAMES, GAME BOARD AND PLAYING CARDS FOR USE THEREWITH

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from United States Provisional patent applications numbers 61/297,567, 61/303,991 and 61/373,778, filed 22 January 2010, February 12, 2010 and August 13, 2010, respectively. The entire contents of each of these applications are incorporated herein by reference.

TECHNICAL FIELD

This invention relates to an active learning system and method and to board games and cards games employing active learning methodology. The invention is especially applicable to game-playing systems and methods of the kind which employ a game board and playing cards or question cards, whether physical or virtual/computer-based.

Embodiments of the invention may employ a so-called Active Learning Methodology intended to facilitate learning of educational material using a competitive, performance-based, game-playing environment that may involve winning, losing, rewards, and challenges.

This invention is also applicable to games related to chemistry and especially to card games related to the Periodic Table of Chemical Elements.

BACKGROUND

"Active learning" refers to learning that involves more activity on the part of the learner than simply listening and watching. Without active learning, students may not be engaging in learning material beyond simple memorization. Active learning often emphasizes students working in cooperative and collaborative groups and requires students to take increased responsibility for their learning. A sense of competition and one's status in the group(s) encourages students to work hard. The recognition and respect that come from successful participation in an active learning session "fuel participation and invest the participants in the experience because it transforms knowledge into social capital". Not only do participants "own" their learning because they participated actively
in the process, but also ownership is worth something in a social context where one's status is derived from peer acknowledgement, i.e., by other participants. This incentive may be more powerful than grade point average or teacher approval.

Educational games, using game boards, playing cards or computers and the like, may foster active learning by requiring interactivity, peer-learning and team work, promoting collaboration, and increasing motivation. Games can be used to address cognitive psychomotor and affective domains of learning and to support different learning styles. Perhaps most significantly, games respect a performance-based environment. One can not be passive when playing a game. Learning through performance requires active discovery, analysis, interpretation, problem-solving, memory and physical activity which result in the sort of extensive cognitive process that deeply roots learning in a well-developed neural network. To some extent, this approach is followed in higher education and professional education, with the teacher or mentor providing guidance.

Known board games involving a game board, question/answer cards and player tokens/markers can generally be classified into either of two groups, namely entertainment and education, according to their primary objective, though many board games serve both purposes. As the name suggests, the primary objective of an entertainment board game is to give some entertainment to the player(s). The primary objective of an educational game, however, is to help the player(s) in their education or learning or training and uses game-playing so that the learning process is fun.

Primarily-educational board games are known to use question cards to pose questions about a selected subject and a game board to track each player's progress. Each player proceeds along a prescribed path on the game board by providing correct answers to such questions, in some cases with no assistance or prompting, in other cases by selecting from a list of possible answers, i.e., multiple-choice, and so on. A player must complete the path ahead of the other players in order to win the game. A player may answer the questions based upon the player's knowledge of the selected subject, or, if that is deficient, simply make a guess. In general, any education or learning results from the players being given, and then remembering, correct answers to questions they were unable to answer based upon their knowledge of the subject when the question was
posed. This includes correct answers given by, or to, other players during earlier gameplay. Thus, the players will improve their knowledge of the subject by assimilating the information contained in the answers they did not know before.

One example of an entertainment board game is the well-known game Trivial Pursuit™ by Hasbro S.A., Switzerland which comprises a game board and a set of playing cards containing questions about "trivia". Replacement sets of question cards are available for different topics. As the term "trivia" implies, the questions and answers in any particular set, however, as formulated, are not constrained to a specific course of study or predetermined subject matter to be learned by the player(s). While players might learn from answers given during play, such learning would be incidental. Also, the questions are randomly selected, so learning is somewhat haphazard.

There remains a need, therefore, for an active learning system and method, and a board and/or card game employing active learning methodology, which better facilitate the learning of a body of prescribed subject matter.

Periodic Table Card Game - Background

A further need concerns science education specifically. Fundamental science education entails a knowledge of the chemical elements which constitute the building blocks of all matter in the known universe, and the various compounds resulting from chemical reactions between these chemical elements. The Periodic Table of Chemical Elements, which is an integral part of the chemistry curriculum in most schools, is an essential tool for understanding the properties of 118 chemical elements (natural, artificial or whose existence has been predicted) and thousands of chemical compounds resulting from the chemical reactions among them.

In the Periodic Table, chemical elements are grouped on the basis of their properties helps the student to understand and predict the salient and unique features of an element based on the group to which it belongs. Consequently, the Periodic Table is a concise way of communicating the details of an atom of an individual element, such as number of electrons, protons and neutrons, along with the chemical symbol for the element. The position of the element in the periodic table automatically defines the common characteristics of the element and facilitates the prediction of the behavior of the
element while forming chemical bonds with other elements. The position in the periodic table also predicts the shell structure for the neutral atom of the element. Clearly, gaining familiarity with, and, if possible getting a clear understanding of, the periodic table, would represent a milestone of achievement for any serious student of chemistry.

Understanding the fundamentals of chemistry using the periodic table of elements through a conventional approach of reading and memorizing the chemical properties of various elements and numerous compounds formed by chemical reaction among them is a laborious task. Some students may give up the task soon after they start. Some others may find the study of chemistry uncomfortable or unproductive.

Consequently, students are less likely to successfully learn various aspects of chemistry associated with periodic table of elements to a desired or required level of competence. To achieve the desired or required level of competence, it may take much longer to learn the required subject matter than a student is prepared to commit or can afford.

It is known to use chemistry-related games to facilitate the study of chemistry, and particularly the Periodic Table. For example, the book "A handbook of game design" by Henry Ellington, Eric Addinall and Fred Percival, 1982. Kogan Page, London, Nichols Publishing Company, New York, discloses a game known as FormulonTM for use in teaching basic inorganic chemistry to pupils aged roughly 13 to 16 years. The game package consists of a pack of 100 cards plus a three page instructional leaflet. Seventy-eight (78) of the cards represent atoms or ions, twenty (20) represent multipliers (by two or by three) while the remaining two cards are jokers that can be used to represent any other card to make up chemical formulae. This game does not provide complete coverage of the known chemical elements as it is based on a limited set of only 78 atoms or ions of atoms, since the multipliers and jokers do not represent any chemical elements.

Various chemistry-based games have been disclosed in the patent literature. For example, EP0023687, US 7490834 and US20080284104 disclose chemistry-related card or board games but all are based upon only a subset of the Periodic Table of Chemical Elements. Consequently, these known games are not entirely satisfactory learning tools, given the extent of the entire domain of chemical elements known to mankind.
There remains a further need, therefore, for a game that is more suitable for helping students to understand the Periodic Table of Chemical Elements and the way in which they may combine to form compounds.

**SUMMARY OF INVENTION**

Among problems to be solved by, or objects of, the present invention is the need to overcome or at least mitigate one or more deficiencies of known such games, or at least provide an alternative.

Addressing the above-mentioned need for an active learning system and method, and a board and/or card game employing active learning methodology, which better facilitate the learning of a body of prescribed subject matter, according to a first aspect of the present invention, there is provided an active learning system for use by at least one participant, the system comprising a plurality of learning modules whose contents together make up a predetermined corpus of knowledge to be learned, a corresponding plurality of sets of questions and answers, each question-answer set relating to a corresponding one of the learning modules, and rules prescribing a sequence of events constituting a learning session, said events comprising, for said at least one participant, selecting at least some of said learning modules in sequence, for each selected learning module selecting one of the set of related questions for the participant to answer, and recording progress of said at least one participant from a learning session start towards a learning session finish according to whether or not said at least one participant answers the questions correctly.

According to a second aspect of the present invention, there is provided apparatus for use by participants during an active learning session, the apparatus comprising a progress chart and, for each player, a set of learning modules and a marker, the progress chart showing, for each player, a path between a start and a finish, the path to be traversed by the marker of that player as the session progresses, the set of learning modules together making up the corpus of knowledge to be learned by that participant, each learning module having associated therewith a set of questions about the corresponding learning module and either the answer to each of the questions or a link to
the answer, together with a set of rules for the players to follow when conducting the active learning session.

Preferably, during design of the active learning system and apparatus, the contents of the learning modules are selected so as to comprise substantially all principal topics distributed throughout the entire corpus. Likewise, for each learning module, the questions preferably are distributed with respect to the content of that learning module, so as to reflect main items of knowledge contained therein.

Each learning module may comprise an identifier, e.g., a sequence number that associates the learning module with a respective similarly identified (numbered) one of the cells of the path to be traversed. The learning module also may have an associated information module comprising supplemental information relating to the learning module, and/or a summary. Thus, the information module may contain quick reference information on the subject matter contained in the learning module, perhaps with diagrams.

Each participant's progress may be tracked by means of a progress chart containing a path to be traversed by the participant by correctly answering at least some of said questions, progress being recorded by moving the participant's marker along the path. Chance selection means, for example one or more dice, may be used to select both the learning module and the related question to be posed to the participant. The path may be formed by a series of the cells, each representing a step along the path. The series of cells may be numbered sequentially, each cell number corresponding to a respective one of the plurality of learning modules which are numbered according to the same sequence. Selection of a particular cell by a particular participant, e.g., by rolling dice, automatically selects the corresponding learning module and question-answer set. The rules may specify that the participant's marker should not be moved to the cell, however, until the participant has correctly answered one of the questions (or a proxy or substitute question if permitted by the game rules). The participant may simultaneously select the specific question to be posed, for example by rolling two dice at the same time, one to select the cell and the other to select the question.

The progress chart may be demarcated according to the corpus of knowledge and, preferably, is sub-divided into a series of cells to be traversed by the participant's
marker between the start and finish points, each cell corresponding to a respective one of the learning modules, the participant being posed one of the set of questions associated with that learning module when selected, and to which the marker may be moved if and when the question is answered correctly.

The path may be sub-divided into segments, e.g., groups of cells/steps, each participant being required to answer correctly at least some questions corresponding to each segment. The chart then may provide for the player to record completion of each segment. For example, if the cells are arranged in a rectangular matrix, each segment might comprise one row of the matrix. A participant who correctly answered enough questions, and scored a sufficient number using the chance selection device, e.g., dice, would complete the row and use a suitable marker to indicate completion of that row before beginning at the start of the next row.

In some preferred embodiments of this second aspect of the invention, especially those which are virtual or computer-based, the progress chart comprises a subset of the cells of a rectangular matrix of cells. The subset of cells may be selected to define a desired shape for the progress chart, perhaps to reflect the kind of knowledge to be learned, and/or to select a desired path configuration. Thus, selected cells may be "deactivated", the remaining subset of "active" cells forming a desired progress chart and/or path. The selection of the subset may be done by the participant before the learning session begins, or during design of the active learning system. For example, selected cells of an 18x11 matrix might be deactivated to create a progress chart resembling the shape of the Periodic Table of Chemical Elements, the path being defined by the rows of cells.

In preferred embodiments of either of the first and second aspects of the invention, the progress chart for the or each participant depicts the well-known Periodic Table of Elements, each cell of the path and the associated learning module corresponding to a respective one of the chemical elements. Each learning module and its associated question-answer set relate to one of those elements, and both the cell for that element and the associated learning module are identified by the atomic number of the element.
Such an embodiment is particularly suitable for teaching the Periodic Table of Elements as well as chemical compounds and basic chemistry. Notwithstanding that, the same progress chart could be used with sets of learning modules that are not related to chemistry.

If the progress chart(s) is (are) to be depicted on the display screen of a computer or other electronic means, the participant may be permitted to create the progress chart from an MxN matrix of cells, by selecting some cells as "deactivated" and others as "active", the latter depicting, for that participant, the path to be traversed during the session/game.

The rules may prescribe that, during actual play, a first participant asks a second participant a question based on the content of the learning module and evaluates the second participant's answer with reference to the correct answer given in the learning module. If the answer given by the second participant is incorrect, the first participant will read the correct answer. Not only the second participant but also the first participant, and any other participants, may take the opportunity to memorize the answer as the question may come up again during the game.

The rules may also prescribe for the first participant to create a question to ask the second participant instead of one of the questions associated with the learning module. For example, a six-sided dice may be used, but with only five questions associated with each of the learning modules. When the dice shows the number six, the first participant can create a question and ask the second participant to answer it. Creating a question in this way is also part of the learning process. Sometimes it is very hard and most often will require an understanding of the relevant topic, i.e., the learning module.

Such an active learning system and apparatus are appropriate to formal learning situations, but preferred embodiments take the form of board games with the attendant fun and participatory benefits they entail. Thus, preferred embodiments of the active learning system and method use a game board, learning modules each comprising a question-answer set, and other components, such as markers, pawns, dice and so on, together with a set of rules governing game play. The components may include tokens for influencing a participant's progress, such tokens being distributed to the participant(s)
according to the rules. The contents of the learning modules together represent and define the corpus of knowledge to be learned, partially or completely, by playing the game one or more times.

The elements used for playing the game may be physical or virtual. Thus, the game board, learning modules and other components may be implemented as, or displayed (e.g., printed) upon, physical elements. For example, the learning module content may be displayed on one side of a playing card and the related set of questions and (optional) answers or a set of facts on the opposite side. Each of the playing cards may further comprise an information module, conveniently on the same side as the set of questions and answers or facts.

Where the elements are virtual, the game board, learning modules, information modules (where applicable) and other components may be computer-generated using text, video, graphics, cartoons, animation or other artifacts and displayed on the screen of a computer/electronic device, game playing equipment such as iPAD™, Nintendo™, hand-held device such as a personal digital assistant (PDA), so-called "smart phone", and so on. Additionally or alternatively, at least some of the virtual elements might be outputted to the user as audio.

In the context of this specification, the term "information", as in "source of information", is intended to mean a "concrete/realized" collection of study materials and facts that may or may not be organized into a conventional source of information such as a school text book or a military training manual or a Wikipedia™ collection on the internet. In the same context, "knowledge", as in a "corpus of knowledge", is intended to mean the "abstract" envelope of comprehension and understanding intended (expected) to result from the acquisition and assimilation of a collection of study materials and facts, as in "high-school inorganic chemistry syllabus" or first year university physics curriculum, that may or may not be incorporated into conventional source of information such as a text book.

The corpus of knowledge to be learned by a particular participant may be mapped to a single set of learning modules. On the other hand, a corpus of knowledge pertaining to a relatively complex subject matter area may be covered by multiple sets of learning modules. During an active learning session, however, only one set of cards will
be assigned to a single MxN matrix of cells on the active learning progress chart, irrespective of whether the set represents fully or partially the source of information or corresponding corpus of knowledge. Preferably, however, there will be a one-to-one match between the numbers of the learning modules in the set and the cell numbers on the active learning progress chart.

The sets of learning modules (and corpus of knowledge represented thereby) used by different participants during a learning session need not all be identical. For example, two or more sets of the learning modules may be related to the same subject, but represent different levels of knowledge of the subject, different players being asked questions based upon their respective assigned sets of learning modules, thereby allowing participants having different levels of pre-existing knowledge or learning abilities to participate in the same learning session.

Additionally or alternatively, the sets of learning modules may represent different subjects, so that the participants could participate in the same learning session while learning different subjects. For example, one participant might use a set of learning modules relating to basic mathematics, a second participant might use a set of learning modules relating to higher mathematics, another participant a set of learning modules relating to chemistry, and so on.

As a first corollary, a single participant can use this system on physical or computer or electronic (multi-)media for active learning of a single subject area or multiple subject areas during a single session. As a second corollary, multiple players using a physical setting located at a single site or using computer or electronic (multi-)media setting distributed across a networked environment can use the active learning game to learn various kinds of subject matter during a single session. Their progress charts could be similar or different.

The rules may prescribe for a review or learning period, conveniently at the beginning of the active learning session, during which the participants may attempt to assimilate the contents of one or more learning modules about which they may be asked questions when the session begins.

The learning session/game may be stopped and restarted at any time, the respective positions of the participants, for example the last cell numbers occupied by the
participants' respective markers, being recorded or remembered for when the session restarts.

The tokens may enable a participant to progress more quickly, for example by skipping a number of cells. The tokens may comprise cards. Depending upon the rules, the tokens may be assigned to particular cells on the board before the session commences and may be awarded, perhaps as a "reward", to the participant who, during the session, enters that particular cell.

In the computer or electronic (multi-)media version of the system, a token could be sponsored by a third party and could be "inserted" into the game dynamically from an external source using, for example, a web service such as that provided at (http://en.wikipedia.org/wiki/Web_service) or similar technologies. The token could be accompanied by advertisements to promote products and services provided by the third party.

In one preferred embodiment of the first or second aspect of the present invention, components for use with the active learning system/methodology include a game board, a set of playing cards, a set of dice, a set of reward tokens and a set of markers.

According to a third aspect of the invention, there is provided a game board for use in an educational game to learn about basic chemistry, specifically one or more of the Periodic Table of Elements, chemical compounds and basic chemistry, the game board comprising, for each participant/player, a depiction of the Periodic Table of Elements.

According to a fourth aspect of the invention, there is provided a method of creating an active learning system comprising the steps of extracting a corpus of knowledge from a selected source of information, parsing the corpus into a plurality of learning modules whose contents are to be learned, devising for each of the learning modules either or both of a set of facts about said learning modules and a set of questions about said learning modules to be answered by a participant, optionally together with a corresponding set of answers, and preparing rules specifying that during a learning session/game each player must answer correctly a selection of said questions in order to progress from a starting point to a finishing point of the learning session/game.
According to a fifth aspect of the invention, there is provided a method of designing a game board and a game board resulting therefrom wherein cells of an MxN matrix of cells are designated as active or inactive such that the active cells form a desired progress chart for each participant whereby that participant's prowess in correctly answering selected questions may be tracked.

Addressing now the above-mentioned need for a game that is more suitable for helping students to understand the Periodic Table of Chemical Elements and the way in which they may combine to form compounds, according to a sixth aspect of the present invention, there is provided an active learning educational card game comprising a set of cards and rules for playing at least one card game using said set of cards, each of said cards representing a respective one of the chemical elements listed in the Periodic Table of the Chemical Elements and carrying information about said one of the chemical elements, the set of cards comprising a card for every one of the known chemical elements listed in the Periodic Table of Chemical Elements, the rules prescribing for cards to be distributed to the players who, in their turns in a particular round of the game, attempt to earn cards and/or to form chemical compounds with cards, points being scored according the nature of the cards used or the nature of the compound formed, or both.

Preferably, in embodiments of this sixth aspect the set of cards includes cards for all elements, whether naturally occurring or artificially created; or even predicted but not found, as was the case with element 117 until very recently.

The rules may prescribe for substitution of cards predefined as equivalent or belonging to a particular group of the Periodic Table of Elements. For example, the rules may prescribe cards to be element-substitutable, column-substitutable, row-substitutable, or prescribe other criteria defining a group of cards substitutable with each other.

Embodiments of the sixth aspect of the invention may further comprise a reference chart or board depicting the Periodic Table of Chemical Elements for use during the game.

Embodiments of the sixth aspect of the invention may further comprise a reference listing of chemical compounds to which the players may refer to determine whether or not a combination of cards played by a player do form a recognized
compound. The rules may prescribe that only compounds on the list are to be accepted as valid and recognized during game play.

In preferred embodiments of the sixth aspect of the invention, at least some of the cards carry additional information or insignia and the rules prescribe for the use of those cards to influence the progress of the game. Thus, cards representing radioactive material, such as uranium, may carry a radioactive indicator, such as the symbol used in the nuclear power industry, and the rules may prescribe for such cards to be used to "trump" a particular round of the game.

Advantageously, embodiments of the sixth aspect of the invention can be used for teaching the periodic table of chemical elements as well as chemical structures to students with little or no prior understanding of chemistry; or to enhance or reinforce the understanding of chemical elements and chemical reactions possessed by more advanced students of chemistry.

In embodiments of the sixth aspect of the invention, the information carried by the cards may be such that repeated playing of the game may teach the players aspects of all known elements presented in the periodic table, such as the atomic weight, atomic number, name and symbol, the position in the periodic table and what the position means, and/or the valence electron shell structure, through the exposure to these aspects while playing the game. In addition, like a child building a language vocabulary through word games, the game players will be exposed to several chemical compounds through the game. While competing and interacting during the course of the game, the players/students will be exposed to, and may acquire, knowledge about all known basic chemical elements, hundreds of existing known chemical compounds, radioactive elements and noble gases. Embodiments of the invention thus offer an interactive and alternative teaching method to that of common text book memorization to learn about chemical elements and compounds, and the Periodic Table of Elements.

Embodiments of the sixth aspect of the invention may share cards with embodiments of the foregoing first through fifth aspects of the invention.

Various objects, features and advantages of aspects of the present invention will become more apparent from the following detailed description, taken in conjunction
with the accompanying drawings, of preferred embodiments of the aspects of the invention, which description is by way of example only.

**BRIEF DESCRIPTION OF DRAWINGS**

In the drawings, identical or corresponding elements in the different Figures have the same reference numeral, where appropriate with a different suffix or subscript.

- Figure 1A illustrates aspects of the conceptual design of an educational system and method embodying this invention;
- Figure 1B illustrates different aspects of an alternative conceptual design of an educational system and method embodying this invention;
- Figures 2A and 2B illustrate conceptually the content and layout of obverse and reverse sides, respectively, of playing cards comprising components of an educational system and method embodying this invention;
- Figures 2C and 2D correspond to Figures 2A and 2B and illustrate specific examples of information printed upon the playing cards;
- Figures 3A, 3B and 3C illustrate alternative game boards for other embodiments of the invention;
- Figure 4 is a top plan view of a preferred game board for use when using the educational system and method to learn about chemical elements listed in the Periodic Table of Elements;
- Figures 5A and 5B illustrate, as an example, obverse and reverse sides of a playing card for the element uranium suitable for use with the board of Figure 4;
- Figures 5C and 5D illustrate obverse and reverse sides of an alternative playing card representing the element uranium but having different content from the card of Figures 5A and 5B;
- Figures 6A, 6B, 6C and 6D illustrate, as examples, obverse sides of four other playing cards suitable for use with the game board of Figure 4;
- Figure 7A is a side view of a player's marker or movable pawn for use with the game board shown in Figure 4;
- Figure 7B is a top view of a set of (optional) game tokens for use with the game board shown in Figure 4;
Figure 8 illustrates an alternative embodiment of board game for two players;
Figure 9 illustrates an active learning game board depicting four progress charts, each comprising an MxN matrix in which each cell depicts one or more items of Canada's Food Guide as developed by Health Canada;
Figure 10 illustrates an active learning game board depicting four progress charts, each comprising four double-helix portions, representing the structure of DNA;
Figure 11 illustrates the logical organization of various elements and the design of the active learning system using a game board and learning modules/cards as illustrated in one or more of Figures 1 to 10;
Figures 12A, 12B, 12C and 12D illustrate playing cards representing four chemical elements;
Figures 13A, 13B, 13C and 13D illustrate alternative playing cards for the same four chemical elements;
Figures 14A and 14B illustrate obverse and reverse sides of a playing card for the radioactive chemical element uranium;
Figure 15 illustrates a chart or board having four depictions of the Periodic Table of Chemical Elements;
Figure 16 is a flowchart depicting dynamic sponsorship during the use of an on-line, network- or computer-based embodiment involving a sponsorship client, a sponsorship manager and an active learning system; and
Figures 17A, 17B, 17C and 17D illustrates alternative, simplified playing cards.

DESCRIPTION OF PREFERRED EMBODIMENTS

Before preferred, specific embodiments of active learning systems and methods, for example educational board games, are described, the basic concepts of at least preferred embodiments of the invention and the process of designing the components of the system, including sets of learning modules for a particular corpus of knowledge to be learned, will be described with reference to Figures 1A and IB.

The design of the components of the system for active learning of a particular subject starts with the identification of a source of information encompassing the
corpus(es) of knowledge to be learned. Examples of such a source include, but are not limited to, traditional text books in any area of subject matter, school or academic syllabuses and course content, curricula and guides for competitive examinations like Scholastic Aptitude Test (SAT), Graduate Management Admission Test (GMAT) and Law School Admission Test (LSAT) and training manuals, such as the manual for operation of a fighter jet or other aircraft.

As illustrated in Figure 1A, a corpus of knowledge K to be learned is extracted from a source of information S, for example a text book, and subdivided into snippets of information that can fit on one side of a playing card to create a set of learning modules LI - LN, where N is the number of learning modules in the set, whose contents comprise the corpus K. It should be noted that the playing card could be either a physical card or a virtual card displayed, for example, on the screen of a multimedia device in the case of an electronic or computer version of the game. For ease of description, no distinction is made here between physical and virtual or multimedia versions.

Each individual learning module \( L_i \), is a collection of one or more fine grain learning concepts. For example, a learning card in the area of physics may contain an information module on Newton's First Law of Motion and the subsequent card may contain information on Newton's Second Law of Motion, followed by a card on Newton's Third Law of Motion. It is also possible that, in another set or sets of learning cards intended for use in a detailed learning of Physics, several cards, instead of a single card, may contain information on Newton's First Law of Motion.

A simplified and specific example of the process for preparing a set of learning modules of the kind used in embodiments of the invention might comprise the following steps:

(i) Take a source of information such as a text book.
(ii) Copy the information content page by page to create learning modules.
(iii) Create corresponding training modules containing questions and answers based on that learning module (a specific page in the text book).
(iv) Create an information module by summarizing the page content.
(v) Assign the learning module to one side of the card and the training and information module to other side.
This simplified process may result in an inefficient set of cards as the information content of any given page in a book may be too diluted or incoherent as it is a small piece in a big puzzle organized into paragraphs, chapters and sections. A more efficient approach would be to work with the corpus of knowledge contained within the book, rather than the book itself. Thus, it is preferable to create the learning modules using the corpus of knowledge derived from these original sources of information (say the GMAT guide) rather than simply copying the GMAT book page by page onto a set of cards.

It is also preferable to create the learning modules $L_i - L_N$ by sequentially "traversing" subsets of the corpus of knowledge $K$ to systematically build the cumulative knowledge encompassed by the learning objectives of the original source of information $S$. Such "traversing" involves extracting the subsets or portions in an orderly fashion, according to a logical order of presentation of the discrete portions of the corpus. Such sequential traversing of subsets facilitates gradual, cumulative learning step-by-step and is used in most if not all areas of teaching and instruction. It starts with teaching of basic concepts, moving to logically connected intermediate steps which in turn lead to advanced concepts. For example: In a language curriculum for primary/elementary grade students, one sequential traversing (step-by-step) approach for developing writing skills (the learning objective) would start with learning alphabets, followed by words, followed by rules of grammar and sentence structure and, finally, learning to write sentences, paragraphs and essays. All alphabets, but not necessarily all words or grammar rules, should be learned before learning to write a sentence or a paragraph. Starting with alphabets, then proceeding to words, sentence structure, grammar rules and then start writing sentences, paragraphs and essays constitutes "traversing" of the curriculum in a sequential manner. In a similar way, the designer of an active learning system decides the most suitable sequential traversing of the corpus of knowledge to create the set(s) of learning modules.

The corpus of knowledge representing a given source of information may be mapped onto a single set of playing cards for use in conjunction with a progress chart or game board. If the source of information is a particularly large book, its information may be divided into several corpuses of knowledge and a set of cards created for each
corpus; in other words, a relatively extensive or complex subject matter area may be covered by a plurality of sets of playing cards.

That said, during a learning session or game play, only a single set of cards will be assigned to a single side of the game board, or to a particular participant's progress chart, irrespective of whether the set represents the corpus of knowledge fully or only partially. The only constraint at this stage is that there should be a one-to-one match between the card number and the cell number on the progress chart/game board. Thus:

(1) The number of corpuses and therefore the number of sets of playing cards depends upon the size of the information source.

(2) A simple source of information (e.g., primary school science/physics) may have only one set of cards whereas a complex source (e.g., city by-laws) may result in multiple sets of cards.

(3) The number of cards in each set of cards depends on the progress chart/game board to which these cards are assigned. For example, a 50 cell progress chart/game board requires a set of 50 cards.

(4) The number of sets used on a board depends on the layout of the game board. For example, a two-sided board, i.e., having two progress charts, will accommodate a maximum of two players (teams) whereas a six-sided board having six progress charts can accommodate a maximum of 6 players.

(5) Which sets of cards are used on each side of the progress chart/game board is a decision made by the players at the start of the play/learning session. For example, subject to the selection being acceptable to all of the players, three players can conduct a learning session using three sets of identical cards all relating to Nuclear Physics; or three sets of cards relating to school science, university physics and economics, respectively.

Once defined, each learning module \( L_n \) is printed on one side of a respective one of a corresponding set of playing cards \( C_i - C_N \); the set of playing cards together thus represent the corpus of knowledge \( K \) extracted/derived from the original source of information \( S \). The \( N \) cards in the set are numbered sequentially. It will be appreciated that, if the educational system and method use a computer rather than physical cards, the
learning modules need not be "printed on playing cards", but could be depicted in any convenient way. Even so, it might be preferable to show them as playing cards.

The dimensions of the playing card are appropriate to the playing medium and the learning module. For example, a hand-held card may be dimensioned so that it can be held in the hand comfortably whereas an electronic medium version of the card might have dimensions convenient to the viewing area of the electronic medium.

Figure IB illustrates a variation of this conceptual design. Whereas Figure 1A illustrates a single corpus of knowledge K corresponding to a source of information S, Figure IB illustrates a plurality of corpuses of knowledge KJ-KM identified within the single source of information S. A plurality MN of sets of learning modules are derived from these corpuses to create a corresponding plurality (M) of sets of (N) playing cards, each set corresponding to a respective one of the corpuses. For purposes of illustration and description, Figure IB shows six corpuses, i.e., M = 6, but it will be appreciated that M could be fewer or more than six. Thus, six corpuses K1 - K6 are extracted from information source S and sequentially traversed to create six sets of learning modules L11 - L1N; L21 - L2N; ..., L61 - L6N which are printed on respective sets of playing cards C1i - C2N; C2 - C2N; ..., C6i - C6N. The six sets of playing cards together represent the information extracted from the single source of information S. It should be noted that not all of the information of the source need be extracted. The information extracted, i.e., encompassed by the corpus(es), constitutes the knowledge to be learned.

It should also be noted that, when each corpus is defined by a set of learning modules each of which is open-ended, the learning module may be left blank. An example might be a game based on the Central Intelligence Agency's World Fact Book, in which each country is mapped onto a card. The content of the learning module associated with each country would be enormous and could not readily be covered by a single learning module. At the same time, further sub-division of the corpus of information is not possible as it may violate the atomicity of the corpus of information associated with an individual card. In this case, the learning modules on the cards are left blank and the players are free to refer to any external source to learn about the countries.

Another example of the situation is a game based on the Periodic Table of Elements, in which each card represents an element and the corpus of knowledge associated with it
could be enormous. As a consequence, the learning modules on the cards are left blank and the players are free to refer to any external source to learn about the elements.

Figures 2A and 2B illustrate the general layout of obverse and reverse sides, respectively, of an individual one \( C_n \) of the playing cards and Figures 2C and 2D illustrate specific examples of content. Thus, Figure 2A shows a learning module \( L_n \) printed on the obverse side of the playing card \( C_n \) and Figure 2B shows a corresponding training module \( T_n \) printed on the reverse side of the playing card \( C_n \). The training module \( T_n \) comprises a set of facts or a set of questions related to the learning module \( L_n \) or a set of questions and either the corresponding answers or links/pointers/keys to the corresponding answers (such as location/line number/paragraph number) in the learning module \( L_n \). (If the system is deployed on a computer, the links or pointers could be software-based, e.g., Hypertext links).

The reverse side of the card \( C_n \) also carries an information module \( I_n \) which includes the number XY of the playing card \( C_n \), in the numbering sequence of the set of cards \( C_{1-N} \). The information module \( I_n \) may also comprise either or both of a summary of the learning module \( L_n \) and additional information, such as diagrams that may be associated with and illustrate the specific topic addressed in the learning module \( L_n \). As shown by way of example in Figures 2C and 2D, a typical playing card for active learning in the area of Physics might have printed upon its obverse side a learning module \( L_n \) comprising an explanation of Newton's laws of motion (Figure 2C), and might have printed upon its reverse side (Figure 2D) a training module \( T_n \) comprising a set of questions and answers about Newton's law of motion based upon the information in the learning module \( L_n \), together with an information module \( I_n \) comprising a corresponding set of equations and the card number 63. One or more sets of playing cards of this kind can be used alone, or in conjunction with a progress chart/game board, to facilitate active learning of the corpus of knowledge.

**Game Boards/Progress charts**

Typically, if a single participant or player is involved, a single set of playing cards may be provided, together with a single progress chart to track progress during a learning session/game. If two or more participants/players are involved, two or more sets
of playing cards may be provided along with two or more progress charts, one set of playing cards and one progress chart for each player. Conveniently, the progress charts will be depicted upon a game board.

Examples of such game boards and associated sets of cards are illustrated conceptually in Figures 3A, 3B and 3C. All of them have in common a progress chart or table for each player. Each progress chart or table is used in monitoring the player's progress, contingent upon answering questions on the playing cards, between a starting position and a finishing position, as each player tries to be the first to reach a position where they can be given, and answer successfully, a final question, and thereby ending the game.

The progress charts may take a variety of forms, ranging from printed charts to sections of game boards to computer displays. Examples of game boards comprising progress charts each in the form of an MxN matrix for each player/participant will now be described with reference to Figures 3A, 3B and 3C. Each progress chart is used in monitoring the player's progress, contingent upon answering questions on the playing cards, between a starting position and a finishing position, as each player tries to be the first to reach a position where they can be given, and answer successfully, a final question, thereby ending the learning session/game.

Thus, Figure 3A illustrates a two-player game board 300A having a rectangular central area 302A and two generally-triangular tables 304A one on each of its opposite sides, one table for each player. Each table 304A comprises a plurality of cells 306A arranged in several rows of different length, a longest row adjacent the edge of central area 302A and a shortest row furthest from the central area 302A. Two sets of playing cards C₁ - Cₙ are provided, one for each player. The number (N) of cards in each set Cᵥ-Cᵥ is equal to the number of cells in each table 304A. For purposes of illustration, Figure 3A shows 12 cells in each table 304A. It is unlikely that N would be fewer than 12 but, in practice, it may be, and probably would be, greater. In this specific example, the corpus of knowledge represented by the playing cards is School Physics and is the same for both players. It should be noted, however, that the corpuses need not be the same for both players.
In the central area 302A there is provided a star in a circle 308A representing a "winner's circle" and, between the circle 308A and each of the tables 304A, a pair of stars 310A representing intermediate positions attainable by the corresponding player upon successfully answered enough questions to progress beyond individual rows of the table of cells. More particularly, each star 310A corresponds to one row of the table 304A and a player may place a marker on the star 310A on completion of that row, by obtaining suitable scores (e.g., with a dice) to traverse the cells and answering questions selected from cards corresponding to selected cells in the row.

Figure 3B illustrates conceptually a game board 300B for use by up to four players which, in effect, is a four-sided version of the game board 300A of Figure 3A. In this case, each table comprises three rows of cells 306B each include an equal number of cells, specifically six. In addition, the four corpuses used by the four players, respectively, are not the same. As shown, by way of example, Player 1 has a set of playing cards C1_1 - C1_N relating to School Physics, Player 2 has a set of playing cards C2i - C2N relating to School Biology, Player 3 has a set of playing cards C3_1 - C3_N relating to School Chemistry and Player 4 has a set of playing cards C4i - C4_N relating to School Geography.

It will be appreciated that the game board need not be rectangular, but may have any of a variety of shapes. For example, Figure 3C illustrates conceptually a six-sided game board 300C for use by up to six players which, basically, is similar to the game boards of Figures 3A and 3B but with a hexagonal central area 302C and six tables 304C each containing twenty-four cells 306C in four equal rows. The six sets of playing cards shown in Figure 3C are simply referenced C1, C2, ..., C6 and each may represent the same corpus of knowledge as the other sets; or a different corpus. A slight variation, as compared with the game boards of Figures 3A and 3B, is that the game board of Figure 3C has three sets of intermediate position stars 308C between each of the tables 302C and the centre "winner's circle" and star 308C.

In each of the tables (MxN matrices) of the game boards of Figures 3A, 3B and 3C, the cells are numbered, each of the cell numbers matching a number XY on a corresponding one of the associated set of playing cards, conveniently marked on the upper right-hand corner of the card as described above with reference to Figures 2A and
2C (and as shown in Figures 5A, 5C and 6A-6D to be described later). As mentioned above, each of the intermediate position stars 310A/B/C corresponds to a row of the corresponding player's table 304A/B/C. Traversal of that row by successfully answering one or more questions may qualify the player to insert a row marker, for example a pawn playing piece, upon the corresponding intermediate position star. It should be noted that, as a general rule, the number of questions and successful answers needed to traverse a row will be fewer than the number of cells in that row, because, as will be described later, the number of cells traversed for a particular correct answer may vary. In particular, the number of cells traversed will depend upon the throw of a dice or other chance selection.

Assuming, for example, that the board has 4 rows and 18 columns and the player's first marker/pawn is on row 1, cell 16, during the player's next throw of the dice, the position dice indicates 6, the player answer the questions correctly and moves the playing piece six cells. The first row has only 18 cells, so the playing piece will be moved to cell number 22, i.e., the fourth cell of the second row (not in the 19th cell, where the second row begins) and a row marker/pawn 602 will be placed in the player's circle to indicate completion of the first row.

It should be noted that the number of intermediate stars 308A/B/C is one less than the number of rows of cells and one less than the number of markers/pawns each player will have. Once a player has positioned a marker pawn upon each intermediate position star 310A/B/C, and then has completed the final row, a successful answer in the player's next turn may enable the player to place a marker upon the "Winners circle" position star 308A/B/C and win the game, as will be described in more detail later.

It should also be noted that each of the progress charts/tables 304A/B/C could be created from a single large matrix by designating some cells as "inactive", the remaining "active" cells forming the progress chart/table. This unique feature (with respect to prior art board games) enables the game designer to determine the configuration of the progress chart/table that is more appropriate/suitable for a given subject matter.

Moreover, as indicated earlier, movement of the players' pawns/pegs within the progress chart need not be rectilinear, namely along rows or along columns. The path of movement may be partly along a row and partly along a column, or vice versa, though
it will usually be necessary for the cells in the path to be contiguous. Movement also may depend upon the shape of the progress chart or cell distribution on the board. For example if the progress chart is star-shaped, then the movement may be along neither a column nor a row (of a matrix).

Periodic Table of Chemical Elements Board Game

A preferred embodiment of active learning system, specifically a board game for use by up to four players learning basic chemistry, will now be described with reference to Figures 4, 5A-5D, 6A-6D, 7A and 7B. The board game comprises a game board 300 as shown in Figure 4, a pair of dice or other chance selection means (not shown), a set of playing cards C1 - CN (Figures 5A - 5D and 6A - 6D) per player, a set of markers (Figure 7A) per player, and a set of rules. Optionally, the board game may include sets of reward tokens (Figure 7B) for use if desired and agreed upon by the players before the start of the game.

The game board 300 is suitable for use by up to four players (or teams) in a learning session (game-playing session) relating to the subject area of chemistry and the Periodic Table of Elements. Game board 300 comprises four tables 302/1, 302/2, 302/3 and 302/4, one for each of four players 1-4, arranged around, and defining therebetween, a central rectangular play area 304. Each cell of each of the tables 302/1-302/4 is identified by a cell number in the range 1-118. It will be seen from Figure 4 that the spatial distribution of cells in each of tables 302/1-302/4, and the numbering system used to number its individual cells, are identical to the Periodic Table of Elements in Chemistry. Hence, in each table the cells are arranged in nine rows. (Although element 117 has not yet been discovered, it is included because it has been named and its properties predicted.)

Four playing circles 306/1, 306/2, 306/3 and 306/4 each adjacent the middle of a respective one of the tables 302/1, 302/2, 302/3 and 302/4, are printed in central play area 304, together with a central, common "winner's" star/spot 308. Each of the playing circles 306/1, 306/2, 306/3 and 306/4 comprises eight spots 310 corresponding to the first eight rows of the associated table 302. The central winner's star/spot 308 corresponds to the ninth row of the table 302.
Linear staging areas 312/1, 312/2, 312/3 and 312/4 are provided at the outermost edges of the periodic tables 302/1, 302/2, 302/3 and 302/4, respectively, for storing each player's pawns 702. As shown in Figure 4, each of the staging areas 312/1-312/4 has nine locations for storing the movable pawns 702. In addition, four linear card-holder strips 314/1, 314/2, 314/3 and 314/4 extend along the four edge portions, respectively, of the board 300, each for use by the corresponding player. The card-holding strips 314/1, 314/2, 314/3 and 314/4 each comprise slits or grooves for holding one of the four sets of playing cards. Each player will hold in their card-holding strip 314 the set of cards of another player who is to be asked questions from that set of cards. For example, card-holding strip 314/4 along the edge of the board adjacent Player 4 will hold the playing cards of Player 1, i.e., the cards from which Player 2 will select a card to pose a question to Player 1. This assumes that play proceeds clockwise with each player being asked questions by the immediately preceding player. It is envisaged that such card holding strips might be replaced by some other means of storing the cards conveniently; or even omitted entirely.

In addition, four individual corner play areas 315/1, 315/2, 315/3 and 315/4, shown as large stars, are provided at the four corners of the board, respectively.

Figures 5A and 5B illustrate, as an example, obverse and reverse sides, respectively, of playing card C92, i.e., for the element uranium (atomic number 92).

Figures 5C and 5D illustrate, also as an example, obverse and reverse sides of an alternative playing card C92, which also is for the element uranium. A comparison of Figure 5B with Figure 5D and Figure 5A with Figure 5C reveals that the contents of their respective learning modules differ as do the contents of their respective information modules. Accordingly, the sets of questions in their training modules differ too. These alternative playing cards would belong to different sets of playing cards which could be used during the same active learning session/board game by different players, perhaps having a different pre-existing knowledge of chemistry.

Figures 6A, 6B, 6C and 6D illustrate the obverse sides of four playing cards used with the game board 300. The four cards C1, C63, C92 and C18 are for the chemical elements lithium (Li), europium (Eu), uranium (U) and argon (Ar), respectively, listed among the elements in the tables 402 representing the Periodic Table of Elements. The
reverse sides of the cards are not shown in Figures 6A-6D, but it will be understood that
the reverse side of each card contains a learning module relating to the chemical element
in question and upon which the questions are based and in which the answers may be
found.

The obverse sides of cards C_{3}, C_{63}, C_{92} and C_{18} each carry the corresponding
one of Information Modules I_{3}, I_{63}, I_{92} and I_{18} and Training Modules T_{3}, T_{63}, T_{92} and T_{18}.
The card numbers 3, 63, 92 and 18, respectively, are each shown at the top right corner of
the card, as part of the Information Module. The Training Modules each comprise a list
of five questions. The actual answers are not shown in the training module; instead, the
question numbers constitute keys or pointers to the answers in the learning module on the
other side of the playing card and the training module contains an indication that the
answers can be found in the learning module. Thus, the learning module shown in Figure
5B includes the numbers [1], [2] [3] [4] and [5] to identify answers to those questions. Of
course, the number of questions and answers could be different, if desired.

It should be appreciated, therefore, that a training module may include a list
of facts related to the learning module that can be used to generate questions for the
questioner to pose to the active player, or both questions and answers, or questions only,
perhaps with a pointer to the location of the answer, for example in an accompanying
booklet.

Each of the information modules I_{3}, I_{63}, I_{92} and I_{18} contains the name, symbol,
valence shell structure and atomic number of the element, along with the Column/Group,
e.g., Lanthanides.

In the case of a game based upon physical cards and game board, if reward
tokens are used, they may be distributed to the players before play commences and used
by the players during the course of play. The total number of reward tokens could vary
between zero and the maximum number of active cells on each MxN matrix on the game
board/progress chart; the number to be distributed during a game is a decision made by or
for the players before the start of the game. In this particular example, each player will be
assigned a set of the reward tokens 704. As illustrated in Figure 7B, the reward tokens are
grouped into five different sets, 704A, 704B, 704C, 704D and 704E shown identified by
a star, a hexagon, a rectangle, an ellipse/circle and a question mark, respectively. The
nature of each set of tokens in the context of the chemistry board game will be described later.

In the computer or electronic multi-media version of the system and games, in addition to, or as an alternative to, using reward tokens as described above, rewards could be sponsored by third parties and could be inserted into the game dynamically from an external source. For example, they might be inserted using technologies such as the web services (http://en.wikipedia.org/wiki/Web_service). The reward could be accompanied by game advertisements to promote products and services provided by the third parties.

In addition to the pawns 702 and reward tokens 704A, 704B, 704C, 704D and 704E, chance selection means in the form of a pair of dice (not shown) are provided for use by the players. The dice are referred to as the "question" dice and the "position" dice, respectively, and are each a different colour (or otherwise distinguishable from each other). Each face of each dice has a unique number of dots, e.g., from 1 to 6. When, in his turn, a player rolls the two dice, the score on the "position" dice determines how many cells the player may advance his pawn 702 if he answers the related question correctly. The number of the cell upon which the pawn 702 will land is the number of the playing card which will be drawn and from which the question will be selected. The score on the "question" dice determines which particular question is to be selected from the list of questions on the drawn playing card.

Which of the two dice will be the "position" dice and which will be the "question" dice usually will be specified in the rules. It is envisaged, however, that more randomness might be introduced to the game by allowing the player to decide which one is the "position" dice and which one is the "question" dice after each throw. This option would be decided by the players before the start of the game. In the computer or electronic multi-media version of the system, the question dice and position dice may be replaced by random numbers generated by the computer to determine the cell and the question.
Playing the game

Before play commences, each player is given nine pawns (markers) an example of which is shown in Figure 7A, a set of playing cards and, if included, a set of the (optional) reward tokens (Figure 7B). During game play, each player uses one of the pawns 702 to mark his/her progress along the rows of the table 302. This pawn may be designated a "playing piece" and, if desired, may differ in appearance from the other eight pawns 702. Upon completion of each of the first eight rows, the player places a pawn 702 onto one of the spots 310 of the adjacent circle 306 to record completion of that row.

Once a player has completed eight rows of their table 302, all eight spots 310 of their playing circle will be occupied with pawns 702. If that player is the first to complete the ninth row of the table, upon successfully answering the final question required to complete the ninth row, they win the game and may place their "playing piece" pawn on the winner's circle star/spot 308. Placement of the movable pawns 702 on the spots 310 gives the player a sense of accomplishment as well as providing a visual overview of the state of play/progress. Alternatively, players could use the game board shown in Figure 15 and a single pawn/peg for each player. In this situation, the player will move the pawn along the row of cells from the starting cell to the finishing cell.

Before actual game play commences, the two players each select a set of nine (9) marker pawns 702 of identical color and a respective one of two sets of 118 playing cards $C_{11} \cdot C_{118}$ and $C_{21} \cdot C_{218}$, i.e., equal in number to the 118 cells in each of the tables 302/1 and 302/2. The players place their sets of marker/pawns 602 in the staging areas 312/1 and 312/2, respectively, and their sets of playing cards in the holding areas 314/1 and 314/2, respectively. For quick access, the obverse sides of the playing cards displaying the information module and training module will face towards the player. If Player 1 wishes to learn physics and Player 2 wishes to learn chemistry, Player 1 will have chemistry cards in his holding area 314/1 and player 2 will have physics cards in his holding area 314/2. If both players wish to learn chemistry, but have different pre-existing levels of knowledge of the subject, each will have a set of chemistry playing cards but the contents will be different, for example as illustrated by the playing cards shown in Figures 5A and 5B as compared with Figures 5C and 5D which show the card
for the same cell 92 but with a different content (including the missing element name, a
different set of questions, and so on).

If there are more than two players, each player will hold the playing cards of
the preceding player in the order of play. Thus, Player 2 will hold the playing cards of
Player 1 and use them to pose questions to Player 1, Player 3 will hold the playing cards
of Player 2 and use them to pose questions to Player 2, and so on.

The objective of this board game is to progress throughout all rows of the
progress chart on the game board and gain the right to place the final pawn/marker 702 of
the game on the winning circle star 308, thereby winning the game. The player who
successfully answers enough questions to place all eight "row" pawns on the intermediate
spots 310 of that player's playing circle 306 and then answers enough questions to
complete the ninth row will place their ninth pawn/marker 702 on winning circle star
308.

The game can be played between two or more individuals or teams. In the
case of an electronic or computer medium, the game can be played by a single player
against the computer, the latter serving as the question master. For simplicity, the general
procedure of playing the game between two individuals, or two teams, identified as
Player 1 and Player 2, will be described below. The same board and method can be used
to play the game between four players or teams.

At the start of the game, the Players each place a pawn 702 in the cell
numbered 1 at the bottom left corner of the respective one of tables 302/1 and 302/2, i.e.,
in row 1, column 1 of the table.

To decide which player will start the game, the players throw one or more of
the dice, the player throwing the higher number starting the game (as Player 1).

Player 1 starts the game by rolling the two dice in the individual corner play
area 316/1 at the bottom right of periodic table 302/1. Player 2 uses the count on the
position dice to determine the number of the cell to which Player 1's pawn may be moved
providing Player 1 can correctly answer the selected one of the questions on the playing
card having the same number as that cell. Player 2 picks from Player 1's set of playing
cards Cl to C N the playing card having the same number as the cell, and then asks
Player 1 to answer the question identified by the count of the question dice. For example,
if Player 1's current position is cell number 10 and the position dice shows "4", Player 2 selects playing card number 14. If the question dice shows "3", Player 2 selects question 3 on playing card 14 and poses the question to Player 1. If Player 1 answers the question correctly, Player 1 moves his pawn four cells from cell 10 to new cell 14 on Player 1's table 302/1.

If Player 1 does not answer the question correctly, Player 2 clearly states the answer to the question for the benefit (edification) of Player 1, who does not move his pawn 602, which remains upon cell number 10.

It will be seen from Figures 5A, 5C and 6A-6D that there are only five questions on each card. If the score of the question dice is a six (6), Player 1 (for example) may get a free move to the designated cell (14) without answering a question. Alternatively, Player 1 may be required to answer a question prepared on the spot by the Player 2. These two options are available to the players to make the play easy/fast/difficult or slow. Just before the start of the game, they can decide whether they want a free move or a question created on the spot.

Player 2 continues the game by rolling the position dice and the question dice. When Player 2 is rolling the dice, cards in his area of interest are on Player 1's side of the board and therefore Player 1 picks the card and asks the question. Player 1 determines the number of the cell on Player 2's table 302/2 to which Player 2 may move their pawn 602 and selects the correspondingly-numbered playing card from the deck (set) of cards $C_{21}$ - $C_{2N}$ comprising Player 2's subject matter. Player 1 then poses to Player 2 the question identified by the score of the question dice. If Player 2 answers the question correctly, Player 2 advances their pawn 602 from the current cell on table 302/2 to the cell identified by the count of the position dice; otherwise the pawn 602 remains on the current cell. If the score on the question dice is "6", Player 2 may be presented with the same two options as described above.

That completes one round of the game. Player 1 starts the next round by rolling the two dice again and may or may not "land" on the same cell and thus get the same playing card from which to answer a question. Of course, for Player 1 to get both the same card and the same question on that card, both dice would have to have the same score as previously.
When a player (e.g., Player 1) is in a position to advance to a cell on table 302/1 that has the same number as the cell already occupied by another player (e.g., Player 2) on his/her table (302/2), Player 1 may challenge Player 2 to answer the question identified by the question dice from Player 1's playing card having the same number as that cell. The playing card will be from Player 1's deck of cards C11 - C1N. If Player 2 fails to answer the question, Player 2 moves his pawn backwards to a lower-numbered cell, as decided by the position dice value. For example, if the position dice score is 3, Player 2 moves his pawn back three cells.

Each time a pawn 702 of a particular player, e.g., Player 1, advances to a new row on their table 302/1, a new row marker pawn 702 is placed on a vacant spot 310 on that player's playing circle 306/1. The player, say Player 1, who has traversed all eight rows and has all eight spots 310 of playing circle 306/1 occupied by row marker pawns 702 gains access to the winning circle 308. Once Player 1's final moving pawn 702 reaches (or crosses) cell 118 in Player 1's table 302/1, i.e., the end of the ninth row, Player 1 is declared as the winner and places the final pawn 702 at the center of the winning circle 308 whereupon Player 1 will be declared the winner. It will be appreciated that there will be no question to answer because there will be no further cell number to identify a playing card from which to select the question.

The rules may prescribe that, at this stage of the game, Player 1, must obtain the exact number on the position dice to land upon cell 118. For example, if his pawn is on cell 116, he must roll a "2" and nothing else, to win the game. Alternatively, the rules may prescribe that Player 1 may obtain a score equal to or greater than the number required to land upon the last cell. It is envisaged that the rules may allow for the players to decide between these end-game options at the start of the game. Of course, exact match will make the game more interesting and challenging.

The invention is not limited to the above-described embodiments but rather encompasses various alternatives, substitution and modifications, as will now be described.

Thus, Figure 8 shows an alternative implementation of an active learning game board (800) that can be used by two players and is readily portable. The board has a single progress chart comprising an MxN matrix whose "active" cells form a single
periodic table of elements and two concentric circles 810, one for each player. In order for both players to use the same progress chart (table), each cell of the table contains two marking spots (830). The markers for indicating the progress of the two players comprise two sets of pins, each set being a different colour. The pins conveniently comprise so-called "push pins" of the kind used with cork boards or other suitable material, in which case the game board 800 may be of such a material. At the beginning of the game, each player will be assigned one set of nine pins and will insert a pin into the appropriate marking spot 830 to denote a cell on a row of the periodic table attained. Once a player has advanced across a row of the periodic table, the drawing/paper pin is moved onto a respective one of the concentric circles 810, which may be correspondingly coloured, to indicate the progress made in the game up to that moment. The player who successfully completes the ninth row, as described with respect to the other embodiments, claims victory by sticking the ninth pin into the winning spot 815 at the centre of the concentric circles.

It will be appreciated that such a shared game board having a single shared progress chart could be adapted for use by more than two players simply by adding one or more additional marking spots 830 to each cell, providing one or more additional sets markers (pins) and one or more additional circles 810. It will also be appreciated that the use of a shared progress chart is not limited to portable embodiments of the invention. Others of the above-described embodiments could use shared boards/progress charts, especially computer-based embodiments.

On the other hand, if the markers used by the different participants are sufficiently distinctive, is also envisaged that the marking spots could be omitted and the progress of any reasonable number of participants tracked simply by the cells occupied by their respective distinctive markers.

Likewise, the concentric circles 810 could be replaced by a single circle shared by the different participants, there respective positions around the circle being apparent from their distinctive markers.

It is envisaged that, in any of the above-described embodiments, reward tokens could be associated with various cells on the board to encourage players and to make the playing more enjoyable. Positions and reward (value) associated with a reward
token would be decided in advance, i.e., before the start of the game, by the players or by a sponsor or by a teacher who manages the play. The players could use their reward tokens to enhance their own prospects, for example by moving additional cells or obtaining help with a question, or to impair the prospects of other players, for example by obtaining one or more of their reward tokens.

For example, in one implementation one cell on each MxN matrix on the board is identified as reward cell and 4 tokens of the same kind are added into a common pool of reward tokens assigned to that cell number. When a Player moves to (their pawn lands on) that particular cell on any of the MxN matrices, the Player becomes eligible to receive a reward token (say for example 704) from the common pool of assigned tokens in the game.

Consider, for example, a two-sided version of the game board of Figure 3 (or two players using tables at opposite sides of the four-sided board):

On each side, the third column with 4 cells (Sc/Y/La/Ac) is identified as a reward column. For each cell in the column (4 cells) on each side of the board (2 sides), a reward token is added into a common pool (2 x 4 = 8 tokens). Each time a player reaches the third column, the player transfers a reward token from the common pool to the player's personal pool. The player uses the reward token during any of the subsequent casts of the dice/subsequent rounds in that game. Once the game is finished (by identifying a winner) the reward tokens become worthless.

Some examples of the tokens, associated columns and how the tokens can be used in the game are as follows:

"Sign-on bonus" tokens 704A assigned to column 3 of each table 302. Each time when a player moves to (lands on) this column, the player earns a sign-on bonus. It is a wild card token that can be substituted for any other reward token.

"Pick and choose" tokens 704B assigned to column 6 of table 302. A player can redeem a "pick and choose" token 704B to select a card number and the question number that the player wishes to answer (rather than the question that is asked by the opposing player). The opposing player will pick the specified card from the first player's deck which will be in front of the opposing player. (Player 1 will have cards for Player 2 and Player 2 will have cards for Player 1). From an educational point of view, this reward
token is introduced to encourage players to memorize the question and answer a question the player encountered in the past.

"Call an opponent" tokens 704C assigned to column 9 of table 302. If a player encounters a difficult question during the game, he/she may use one of these tokens 704C to force the opponent to answer his/her own question; the player gets a free move.

"3 steps ahead" tokens 704D assigned to column 12 of table 302. A recipient of one of these tokens may use it during any subsequent move to add three (3) to the count indicated by the position dice. For example, once a player has answered a question for a particular cell correctly, the player can use the "3 steps ahead" token to move his pawn 602 3 extra cells beyond that particular cell. The player may wait until he has answered the question and is ready to move his pawn before deciding to play the token and move the marker by the extra cells.

"Give me a hint" tokens 704E assigned to column 15 of table 302. A recipient of one of these tokens may use it during any subsequent move to get a hint for the answer from the opponent.

A player cannot use a reward token 704 in conjunction with another reward token 704, if he/she has acquired more than one reward token during a game; only one reward token 704 can be used in a given turn (round). The user of 'round' 'turn' etc is causing the confusion. More specifically, each time the dice are cast, the player may end up in a reward cell and thus may earn a reward token. The next time the dice are cast by the same player, he/she can optionally use a reward token earned previously. During a game dice are cast several times by the same player. Each time the player has the option of using a reward token (including the last winning round!) if he/she already earned one.

Once it has been played, a reward token 704 must be discarded; it cannot be used again during that game.

Unused reward tokens 704 can be carried over to subsequent rounds, but cannot be carried over to subsequent games. Thus, if a player receives a reward token during round 1, he can use it during any successive round of the same game. Once the game is over reward tokens are useless for another subsequent game.
It is also envisaged that the reward tokens might be associated with specific cells, perhaps by being placed upon the cell in a manner similar to the bonus cards placed on the wheel in the popular television game Wheel of Fortune™, or by a visual link like the "Daily Double" bonuses in the television quiz game Jeopardy™. (The latter example might be more applicable to a computer-based embodiment). The person in charge of the learning session (teacher in a classroom setting, panel judge in a competition, game show host of a television version) and/or sponsors will decide how many rewards tokens are to be used, where they are to be placed on the game board, and their respective values.

It should be noted that the foregoing reward tokens are given as examples only. Any number of reward tokens of any suitable kind may be provided, though it is desirable for a player to be given a reward token only after giving a correct answer to a question. A sponsor can place a monetary reward for each cell in the game to encourage players to really master a difficult subject. As an extreme example, a wealthy teacher could motivate students to learn Einstein's special relativity theory through active learning game play by offering a reward token worth $100 on each cell on board. That said, it should be noted that, strictly speaking, the game can be played without these tokens.

In the computer or electronic multi-media version of the system, instead of using reward tokens, the rewards could be sponsored by third parties and could be inserted into the game dynamically from an external source using technologies such as the web services (http://en.wikipedia.org/wiki/Web_service) along with advertisements within active learning system to promote products and services provided by the third parties. For example, in a game based on Canadian Food Guide, local restaurants could sponsor some cells of the game with an advertisement of special offer coupon and the player ends up in that cell could win the sponsorship. Similarly, in a game promoting active living and exercise, a local fitness club could place some advertisement on fitness club membership promotions within some cells on the board of the active learning system.

The operation of such dynamic sponsorship in the context of an on-line, network- or computer-based version of the game will now be described briefly with reference to Figure 16, which illustrates a sponsorship client 7001, a Sponsorship
Manager 7003 and an Active Learning System 7005. The sponsorship client 7001 and sponsorship manager 7003 might be network elements, specifically software running on a client computer and a server and the active learning system could be any of the above-described "virtual" embodiments of the invention installed upon any of the above-described platforms capable of communicating with the sponsorship client 7001 and sponsorship manager 7003. A person of ordinary skill in this art would be able to implement such an arrangement without specific instructions, so the following is merely a brief outline of the elements and functions depicted in Figure 16. For further information about such arrangements, the reader is directed to the following disclosures, the contents of which are incorporated herein by reference.

Thus, Sponsorship client 7001, specifically a third party subscriber interacts with the Sponsorship Manager 7003 by way of a network 7007. Similarly, Active Learning System 7005 interacts with the Sponsorship Manager 7003 by way of network 7009. It will be appreciated that networks 7007 and 7009 could be parts of the same network, for example a public data network such as the Internet.

The Active Learning Game Board 7011, as displayed to the player(s), may be similar to one of those described with reference to Figures 3A-3C, 4, 8, 9 and 10. In addition, the displayed board may show, selectively as required, a set of cells with which sponsored rewards may be associated. The software of the sponsorship client 7001, sponsorship manager 7003 and active learning system 7005 will provide for them to communicate to provide the following functionality as indicated by the numbered links:

7013: Subscription, registration communication between the Active Learning System (Server) and the Sponsorship Client.

7015: Communication between the Sponsorship Client and the Sponsorship Manager in the context of publishing and searching sponsorship opportunities.

7017: Communication between the Sponsorship Client and the Sponsorship Manager in the context of publishing and searching sponsorship opportunities.

7019: Communication between the Sponsorship Client and the Sponsorship Manager in the context of submission and storage of sponsorship opportunities.

7021: Subscription, registration communication between the Active Learning Server and the Active Learning Active Learning System.
7023: Communication between the Active Learning System and the Sponsorship Manager in the context of publishing and searching Sponsorship Opportunities.

7025: Communication between the Active Learning System and the Sponsorship Manager in the context of sale and purchase of Sponsorship Opportunities.

7027: Communication between the Active Learning System and the Sponsorship Manager in the context of sale and submission and storage of Sponsorship Opportunities.

7029: Communication between the Active Learning System and the cells on the active learning system game board in the context of inserting of Sponsorship Opportunities.

When using any of the above-described embodiments of the various aspects of the invention, the players may suspend the game at any time and, providing they remember or record their respective positions in terms of the cell number and the reward tokens earned during the game, resume it at a later time. Each moving pawn 702 defines a level in the game. Therefore, the game can be suspended/resumed at any of these levels.

The rules might provide, whether compulsorily or optionally (i.e., the players decide before play commences), for the players to move their respective pawns row-by-row or column-by-column. If the sequence numbers of the learning module are increasing along the rows, the player will move along the row. Otherwise they move along the column. It is also envisaged that the players might not be confined to moving pawns rectilinearly but could move them between rows or columns so long as the cells moved are contiguous.

The board games described above can be used for active learning in any subject area by designing appropriate playing cards and game boards according to the basic principles described with reference to Figures 1A and IB. Whereas the game board 300 described with reference to Figure 4 has four progress charts each in the form of an 18 x 9 matrix having some cells "deactivated" to depict the Periodic Table of Elements, for use by up to four players learning basic chemistry, it is envisaged that the progress charts might take different configurations according to the nature of the subject matter to be learned. Figures 9 and 10 illustrate alternative four-person game boards that are
generally similar to the game board shown in Figure 4 but with different progress charts. Thus, Figure 9 illustrates an alternative four-person game board in which each progress chart comprises an 8 x 4 matrix of which each cell depicts one or more items of Canada's Food Guide as developed by Health Canada. Such a game board might be used by players studying nutrition, for example.

Figure 10 illustrates a four-person game board in which each progress chart comprises a 12 x 4 matrix of cells. In this case, the four rows of the matrix each depict a segment of a double-helix representing the structure of deoxyribonucleic acid (DNA). The 48 cells of the matrix, represented as the nucleotide links of the double-helix, are numbered 1-12, 13-24, 25-36 and 37-48, respectively. Such a game board might be used by players wishing to learn about molecular biology, for example.

It is envisaged that the components of the board game embodiments described with reference to Figures 4, 5A-5D, 6A-6D, 8, 9 and 10 might be supplemented; for example, additional dice may be used, as will be described later. It is also envisaged that not all of the physical components described above will need to be used; for example, the reward tokens might be omitted. Also, one or more separate progress charts, for example commonly-available charts depicting the Periodic Table of Chemical Elements, might be used instead of a game board.

It is also envisaged that the playing cards might be used to play an active learning card game for learning about the elements in the Periodic Table of Chemical Elements, possibly with the game board being used as a reference table, or using a separate chart of the periodic table, or with no game board or chart at all. Such an active learning card game would have rules specifying that players would be dealt a number of the cards and would take it in turn to try to use the cards to form chemical compounds.

The information modules of the playing cards shown in Figures 2C, 5A, 5C and 6A-6D could be modified so as to facilitate such use, for example by replacing the category heading "Column/Group" by special indicators, such as 1, E, G and N, respectively, in a circle and adding a "nuclear" symbol to the uranium card.

There are multiple opportunities for the players to learn or assimilate educational content during the game. Some examples are as follows:
During the (optional) review phase, the players spend time reviewing the learning module at their own pace.

When a first player (Player A) asks the question and the opponent (Player B) answers the question by recollecting the information assimilated during the review phase or known beforehand.

When the first Player A compares the answer of Player B with what is given on the card.

When Player B cannot answer the question correctly, Player A reads aloud the answer and this gives another opportunity for both players to become familiar with and perhaps assimilate at least some of the information content within the learning module.

Other indirect learning opportunities during the play may be provided by introducing bonus cards. For example, Player B may also ask Player A to replace a particular question with another question from a specific card that the player encountered previously and thereby re-confirm a question-answer pair that has already been assimilated. In order to do so, Player B will need to have, and play, a "pick and choose" token 704B.

Figure 11 illustrates the logical organization of various components of the active learning system and board game described with reference to Figures 1 to 10.

PLAYING MEDIA

Embodiments of the present invention may employ physical media, such as paper, cardboard or plastic boards and/or playing cards. Displays of computers and other electronic devices may also be considered to be physical media when displaying game boards, cards or other components. Alternatively, embodiments of the invention may be considered to be implemented using "virtual" game elements, for example using electronic multi-media means comprising, for example, audio, video, graphics, text and animation. Thus, it is envisaged that the invention might be embodied as a computer-based active learning system or game, with the various components depicted pictorially on the display screen. The term "computer-based" is intended to embrace the many kinds of device that have a computer processor and are suitable for game play, such as a
personal computer (Windows/PC/Mac/Unix/Linux to list a few), gaming consoles (examples include but are not limited to Sony Playstation, Microsoft Xbox360 and Nintendo Wii) or hand-held personal communication/entertainment devices (examples including, but not limited to cell phones, iPods™, iPads™, Blackberries™, Playbooks™).

A computer-based version of the learning system or educational game may be played in a networked environment among multiple players located at different physical locations across the network. Embodiments of the invention are very well suited for use with/as electronic books such as Kindle™ from Amazon, either by a single player or by several players. Kindle™ permits an entire book to be uploaded and read page by page, just like regular book. Embodiments of the present invention could be uploaded to Kindle™ and then played between different players in a network environment. This is an ideal method for implementing a self-phased learning module on E-books such as Kindle™.

Embodiments of the invention can be used by a single player, perhaps as part of self-phased learning or training, using a suitably-programmed personal computer instead of another player to pose the questions and verify the answers. The type of computer may be desktop, laptop, personal digital assistant (PDA), mobile telephone (e.g. so-called "smart phone"), game console (hand-held or not), and so on. In effect, such individual-player embodiments of the invention allow the other player(s) to be replaced by the computer; a question will be displayed on the screen and its answer will be entered by the individual player and the corresponding progress across the board will be displayed.

As mentioned above, the progress chart for monitoring progression of the or each participant/player may comprise an MxN matrix. While it would be possible to use all MN cells, it is envisaged that some of the active learning cells in the MxN matrix might be set as "inactive" (null) so that the remaining "active" (or non null) cells form a pre-defined (desired) cell distribution. For example, where \( M = 18 \) and \( N = 9 \), cells might be deactivated to leave a cell distribution resembling the shape of the Periodic Table of Elements shown in Figure 4. The inactive cells will be excluded from the active learning game playing. As a general rule, however, each active cell of the MxN matrix will be
assigned a sequence number and will be associated with an active learning card (playing card) with the same sequence number.

Where, as mentioned above, the active learning session or board game involves a non-participating person, for example a teacher, game show host, and so on, the questions might be posed by that person instead of the other, or another, player.

It should be noted that, although it is convenient to divide the progress chart into segments, each comprising a group of cells which form a row of a matrix, and record completion of a particular segment (row) by placing a marker upon the corresponding intermediate marker 308A/B/C, the progress chart might be divided into groups of cells that are not rows, and completion of each segment recorded by placing a marker 702. This is especially applicable where the matrix is not rectangular. For example, the game board may comprise concentric circles, and the groups of cells may comprise separate circles or segments of circles.

In each of the game boards of Figures 3A, 3B, 3C, 4, 8, 9 and 10, the cells will be numbered, each of the cell numbers matching a number XY on a corresponding one of the associated set of playing cards, conveniently marked on the upper right-hand corner of the card as described above.

As described above, each of the intermediate position stars 310A/B/C corresponds to a row of the corresponding player’s table 304A/B/C. Traversal of that row by successfully answering one or more questions may qualify the player to insert a marker, for example a pawn playing piece, upon that intermediate position star. It should be noted that, as a general rule, the number of questions and successful answers needed to traverse a row will be fewer than the number of cells in that row, because, as will be described later, the number of cells traversed for a particular correct answer may vary. In particular, the number of cells traversed will depend upon the throw of a dice or other chance selection.

Direct one-to-one mapping between a learning module and a page of conventional source of information, as mentioned above, may make the process of active learning laborious and inefficient. Thus, the game designers may derive the active learning cards from the corpus of knowledge associated with the conventional source of information rather than from the source of information itself. This enable the game
designer to apply editorial judgment to manipulate, resize or reformulate the corpus of knowledge inherent to a conventional source of information to make the information module more efficient and relevant to the process of active learning, without strictly adhering to a one-to-one mapping between the number of Active Learning cards (and thus the number of learning modules) and pages in the conventional source of information.

In the above-described embodiments, the training modules contain the questions and either the answers or keys that will direct the player to the relevant portions in the learning module which contain the answers. When embodiments of the invention are to be used for self-training or group-training in complex subject matter areas, for example higher-mathematics or accounting, there could be situations, during the training process, in which intermediate steps taken to reach the correct solution also become as important as the final answer itself. To ensure that the intermediate steps are used/learned, the components also may comprise, for each set of cards, an answer key reference booklet containing the correct answer for each question on each card and an optional description of various steps taken to derive that answer.

Card games embodying the sixth aspect of the present invention used for active learning in the area of Periodic Table of Chemical Elements will be played using a deck of cards comprising one or more sets of cards, the cards in the or each set corresponding to respective ones of the chemical elements listed in the Periodic Table, preferably including those that have been predicted but not yet discovered. Figures 1A, IB, 1C and 1D show obverse sides of four of those playing cards for the chemical elements Lithium (Li), Europium (Eu), Uranium (U) and Argon (Ar), respectively. The reverse side (not shown) of each card is blank/empty, while the obverse side contains an information module comprising information about the chemical element represented by the card.

Figure 4 shows a top view of a playing board 400 suitable for use by up to four players (or teams) when playing a card game embodying the present invention. Game board 400 comprises four tables 402/1, 402/2, 402/3 and 402/4, one for each of four players 1-4, arranged around, and defining there between, a central rectangular play area 404. Each cell of each table 402 is identified by a cell number in the range 1-
118. It will be seen from Figure 4 that the spatial distribution of cells in each table 402, and the numbering system used to number its individual cells, are identical to the Periodic Table of Elements in Chemistry.

The game board 400 and the playing cards shown in Figures 1A, IB, IC and ID are similar to those disclosed in our afore-mentioned United States Provisional patent application No. 61/297,567 which discloses a board game. In embodiments of the present invention, however, these cards have only an information module; no training module or learning module. Also, the game board is simply provided as a reference showing the Periodic Table of Chemical Elements which can be consulted during game play. It will be appreciated that a chart showing a single Periodic Table could be used instead and shared by the players.

Referring again to Figures 1A, IB, IC and ID, the information module of each card shows the following

(i) the element symbol (503) (e.g.: Li, Eu, U or Ar);
(ii) the element name (504) (e.g.: Lithium, Europium, Uranium or Argon);
(iii) the atomic number (or atomic weight) of the element (501) (e.g.: 3, 63, 92 or 18, which is also the card number);
(iv) a category indicator (502) (#, E, G or N), shown encircled;
(v) a series (505) of numbers representing the atomic shell structure of that element (for example 2,1 for Li or 2,8,18,25,8,2 for Eu or 2,8,18,32,21,9,2 for U or 2,8,8 for AR).

It should be noted that, if atomic weight is used as the card number the game could be more complicated as some elements may have the same atomic weight. In such a situation, the atomic number may be used to break the tie to decide which card has higher value.

The card representing the radioactive element Uranium also has a special indicator (506), i.e., a radioactive symbol as used in the nuclear energy industry. This symbol indicates that the element represented on the card is special, in this case radioactive. It also indicates that the card may be played to influence the game in a way that cannot be done by other cards. Other cards in the deck will have a similar information module, but not necessarily a special indicator.
The category indicator comprises either a letter or a number in the range 1-17, both inclusive. The letter may be G, N or E and the number, if present, represents the column of the Periodic Table of Elements occupied by the element represented on the card. The playing cards are grouped into four distinct categories as follows:

- (1) column-substitutable cards (indicated by the column number in the range 1-17, inclusively); [NB: column number 18 is indicated by the N symbol; i.e., the noble elements];
- (2) element-substitutable cards (indicated by the letter E);
- (3) group-substitutable cards (identified by the letter G); and
- (4) noble element cards (identified by the letter N).

Thus, a category (1) card represents an element that belongs to the main body of the periodic table and, hence, is not part of the lanthanides (atomic numbers 58-71 inclusive) and actinides groups (atomic numbers 90-103 inclusive).

During the game, a playing card with a particular column number as its category indicator can be used to substitute for any other playing card with the same column number. Once all participants have played cards in a particular round, the player who played the card with the highest value (atomic number) has the claim to the cards lying upon the table. That player then attempts various card combinations to form chemical compounds, and claims those cards used in the formation as his/her own.

When trying to form a compound, the player may substitute one card (say H) with another card (say Li) in the same column (column-substitutable card).

More particularly, if a player holds two cards representing Hydrogen (H) and Oxygen (O), respectively, and a third card representing Lithium (Li), both Hydrogen and Lithium will have "1" as the column number, so the player could use the Lithium (Li) card to represent a second Hydrogen (H) atom to form water (H₂O).

Category (2) cards identified by the letter E, encircled, as the category indicator, may be referred to as "element-substitutable" cards. These category E cards represent the Lanthanides group 180 of elements (with atomic numbers 58-71 inclusive), shown in the tables 402/1/2/3/4 of the game board 400. A category (2) card can be used as itself, i.e., as an element with a given atomic number, or to substitute for any number of atoms of a given element type in a chemical compound, i.e., it can be
used to represent multiple atoms of the same elements e.g., \((H_2, H_3, O_2, O_3, O_4)\). For example, an element-substitutable card can be used to represent \(H_2\) or \(O_4\) in \(H_2SO_4\).

Category (3) cards may be referred to as "group-substitutable" cards. These category (3) cards represent the Actinides group of elements (with atomic numbers 90-103 inclusive) shown in the tables 402 of the game board 400. A category (3) card is identified by the letter 'G' as the category indicator in the information module and can be used as itself, i.e., as an element with a given atomic number, or to substitute for a group of elements that collectively participate in a chemical reaction. For example, a group-substitutable card can be used to represent \((OH)_3\) in \(Al(OH)_3\).

Category (4) cards may be referred to as the "noble element" cards. These category (4) cards are identified by the letter 'N' as the category indicator in the information module and represent the noble gases in column 18 of the periodic table. The element represented by a category (4) card does not participate in chemical reactions under normal conditions and therefore will not be used to create chemical compounds during the game. Thus, these cards have zero value and cannot be used to claim the right to form chemical compounds. By playing this category (4) card, however, a player can fulfill his obligation to participate in a particular turn or round by contributing a worthless (zero value) card while holding onto valuable cards in his hand, i.e., without sacrificing them.

Playing cards which, like the uranium card shown in Figure 1C, have the nuclear symbol 506 in the information module, correspond to radioactive elements in the periodic table and have special roles in the game. Just like other playing cards, these "radioactive" cards can be used as column-substitutable cards (category (1)), element-substitutable cards (category (2)) or group-substitutable cards (category (3)), depending upon their position in the Periodic Table. In addition, however, these radioactive cards may be played to nullify the current round of the game, in a sense like a "trump" card used in other card games such as whist.

Thus, a player can "challenge" the other players by playing a radioactive card, thereby declaring his intention to "nuke" (bomb) the round. The subsequent players in the same round of the game each have two options; either to counter the challenge and neutralize the "nuke" attack, or leave it unchallenged by playing any of the cards in
hand to fulfill the requirement, in his turn, of placing a card upon the table. If this "nuke" attack is not countered or neutralized, but is left unchallenged, all of the cards played in the round will be set aside from the play and their values will not be used in calculating the score. Typically, a player might try a "nuke" attack if a preceding player played a card with a very high value; unless countered successfully, the nuke attack would spoil the round and stop that preceding player from winning the round. Thus, these radioactive cards may introduce an element of surprise to the game.

To counter this challenge and neutralize the "nuke" attack, a subsequent player in the same round must play another radioactive card having a higher atomic number than the radioactive card used to launch the "nuke attack".

Any of the other subsequent players, following in their turn in the same round, may play another radioactive card having an atomic number higher than the radioactive card(s) already played to neutralize the "nuke attack", and so assume the right to claim responsibility for neutralizing the "nuke" attack.

If the attack is neutralized, the player who neutralized the attack (by playing the radioactive card of highest atomic number in the round) can directly claim all the cards as reward, without using any of them to form any chemical compounds. If more than one player neutralized the attack by playing a radioactive card, the player who played the radioactive card with highest value will be the winner of the round and claim all cards of the round as a reward. The player who launched the "nuke attack" and any player(s) who tried to neutralize the "nuke attack" but were "trumped" by a subsequent player playing a higher-value radioactive card, will not get any cards in that round. Thus, the playing of a radioactive card will result in an "all or nothing" round.

Radioactive card are identified by a radioactive symbol 506.

The players may be given the option of deciding before the start of the game how many times each player may play a radioactive card during a particular game, the default number of times being once. If the players choose to increase the maximum allowable number, or make it unlimited, the result may be a very chaotic game with a very exciting and unpredictable outcome.
Further rules for using the cards in the course of card games embodying the present invention will become apparent from the following description of preferred embodiments.

With a view to resolving disputes, game equipment embodying the present invention may include a reference listing of chemical compounds and the rules then may prescribe that compounds formed during game play must be listed in the reference listing. The following short listing of chemical elements is an example extracted from the on-line encyclopedia Wikipedia™. It will be appreciated that reference might be made, during the game, directly to the Wikipedia™ listing itself, especially if the game is being played using a computer.

Aluminium antimonide - AlSb
Aluminium arsenide - AlAs
Aluminium nitride - AlN
Aluminium oxide - Al₂O₃
Aluminium phosphide - AlP
Aluminium chloride - AlCl₃
Aluminium fluoride - AlF₃
Aluminium hydroxide - Al(OH)₃
Aluminium nitrate - Al(NO₃)₃
Aluminium sulfate - Al₂(SO₄)₃
Ammonia - NH₃
Ammonium bicarbonate - NH₄HCO₃
Ammonium cerium(IV) nitrate - (NH₄)₂Ce(NO₃)₆
Ammonium chloride - NH₄Cl
Ammonium hydroxide - NH₄OH
Ammonium nitrate - NH₄NO₃
Ammonium sulfate - (NH₄)₂SO₄
Ammonium tetrathiocyanatodiamminechromate(III) - NH₄[Cr(SCN)₄(N₃)₂]
Antimony hydride - $\text{SbH}_3$
Antimony pentachloride - $\text{SbCl}_5$
Antimony pentafluoride - $\text{SbF}_5$
Antimony trioxide - $\text{Sb}_2\text{O}_3$
Arsine - $\text{AsH}_3$

**Card Game Embodiment 1**: An Active Learning Card Game For Studying the Periodic Table of Chemical Elements.

The general procedure for playing this card game is as follows:

(i) One player shuffles the deck of playing cards thoroughly and then places the deck of cards on the table or playing zone with the information module sides down.

(ii) The players cut the deck in turn, the player with the highest atomic weight card being the dealer for the first round.

(iii) The dealer takes approximately half of the deck of cards and deals them so that each player will have a specified number cards, for example 5, in hand at the beginning of the game.

(iv) The dealer adds the remaining cards, information module sides down, to the deck of cards already on the table.

(v) Each player in turn picks a single card from the deck of cards to add to the player's hand.

(vi) The player to whom the cards were dealt first starts the game by placing a card, information module side up, on the table/play area. This is followed by other players in sequence.

(vii) At the end of the round (when all players have played a card, information module side up, on the playing area), the player who played the card with the highest atomic number may use all of the cards on the playing area to create as many chemical compounds as possible and acquires the cards that are so used. When making these compounds, the player may use any particular card once only. The objective is to maximize the atomic numbers collected in each round.
(viii) The cards acquired by a player in a particular round will be set aside by the player as earned cards and will not be used when playing subsequent rounds.

(ix) Any cards not used for compound formation in a round will be left in the playing area used and be available for compound formation at the end of the next round.

(x) The player who claimed the current round (by placing the card with highest value or, as described in more detail later, by successfully challenging a "nuke" attack) will start the next round by playing a card. This player starts the next round even if, having won the right to form compounds, he or she could not form any chemical compounds at the end of the current round.

(xi) This process is repeated until all cards in the deck and in the hands of players are used up or no player can form a compound with the cards available either in their hand and/or on the table.

(xii) Each player determines his final score by adding up the atomic numbers (or, optionally, atomic weights, if so decided at the start of the game) from all of the cards that player has earned and set aside. The player with the highest total of atomic numbers is the winner of the game.

(xiii) Alternatively, the players may keep a running total of the atomic numbers (or, optionally, atomic weights, if so decided at the start of the game) of their "earned" cards and the game may end when a pre-defined score has been achieved by one player.

(xiv) A player may skip a round by playing a "noble" card.

(xv) During any round of the game, a player may "clean up" the board by means of a "nuke" attack, i.e., by playing a "radioactive" card identified by a radioactive indicator icon 506 (Figure 1C) to reduce the chance of an opponent winning. If a player plays a radioactive card in a round, all cards in the playing area 404 at the end of the round will be discarded, unless a subsequent player in the same round "neutralizes" the "nuke" attack by playing another radioactive card (see later).

No player may omit placing a card in a round (skip the round) but a player can reduce the loss by playing a noble card subsequent to someone playing a radioactive card.
During the same round, a later player can neutralize the "nuke" attack by playing another radioactive card having a higher atomic number than the "radioactive" card(s) previously played in that round. If more than one player neutralizes the attack by playing a radioactive card, the player who played the neutralizing radioactive card with the highest value (atomic number) will be the winner of the round and can claim all cards played during the round as a reward. (A player who carried out the original "nuke" attack will not get any cards in that round whether the attack is neutralized or not.

A player can use column-substitutable, element-substitutable or group-substitutable cards to form a maximum number of distinct chemical compounds and thus collect maximum number of cards.

A player cannot make compounds with just Actinide and Lanthanide cards alone, if all cards used for compound formation are used in "substitutable" roles (Lanthanides as element-substitutable and Actinides as column-substitutable).

It should be appreciated that the use of special cards to influence play, for example by negating or "trumping" others, is not limited to those representing radioactive material and identified by a nuclear industry icon. It is envisaged that such special cards could represent a variety of elements which have a special relationship or can be used to make compounds having a special relationship. For example, a card carrying a suitable "acid" symbol could be used to "neutralize" a card carrying a "base" symbol, and so on.

**Embodiment 2:** An Active Learning (Board and) Card Game For Studying the Periodic Table of Chemical Elements

An embodiment will now be described which is a card game played between two or more players using a set of element cards as shown in Figures 1A-ID, three dice of a first colour, three dice of a second colour and, optionally, the game board 400 shown in Figure 4. The dice may be conventional six-sided dice, each side of each dice having a unique number or number of dots from 1 to 6.
The face values of the dice are used to select element cards representing elements on the Periodic Table by following the rules as described below. The selected element cards are then used to create chemical compounds (as many compounds as possible with the collected cards in the round). The points scored for the round by the player is the sum of values of element cards that are used in the creation of the chemical compound(s). A simplified form of playing the same game involves calculating the score as the sum of values (atomic number) of the element cards earned by the player; the player does not have to be able to create chemical compounds with the earned cards, in order to earn points. The face values of the dice are used to select the element cards, as follows:

(i) One player starts the game by rolling the set of six dice on the game board 400. The player identifies three first, second and third pairs of dice, each pair comprising one dice of each colour. The player has full freedom to select these pairs of first colour and second colour dice, and identify them as a first, second and third pair, such that they can make a chemical compound and score points, in each round.

(ii) The face value of the first colour dice in each of these pairs represents a row (rows 1 to 6 inclusive) in the periodic table. Hence, the three first colour dice thereby identify, respectively, three rows in the periodic table.

(iii) For the first pair, the face value of the second colour dice represents the column (columns 1 to 6 inclusive) on the periodic table. For the second pair, the face value of the second colour dice plus six denotes the column on the periodic table (one of columns 7 to 12 inclusive). Similarly, for the third pair, the face value of the second colour dice, plus twelve denotes the column on the periodic table (one of columns 13 to 18 inclusive). The (three) second-colour dice thereby identify, respectively, three columns in the periodic table.

(iv) Element cards corresponding to these three pairs of column and row values are picked by the player from a set of playing cards placed at the center of the board (the common playing area).

(v) The player may use one of the tables 402-402/4 on board 400 to identify the card for each element in the Periodic Table.
The player picks a card from the seventh row such that the 7th row column number is same as the number on the first dice representing rows.

The player picks another card from the seventh row such that the 7th row column number is same as the number on the second dice representing rows + 6.

The player picks a third card from the seventh row such that the 7th row column number is same as the number on the third dice representing rows + 12.

The sum of the face values on all three first-colour dice is determined. The player can pick a Lanthanides card i.e., for an element from row 8 of table 402/1 in the position Sum - 2. For example, if the sum is 6 + 1 + 1 = 8, the player can pick the element card from position 8 - 2 = 6 (Eu). There are only fourteen Lanthanide cells, row 8, in table 402/1, so the player does not get a Lanthanides card 180 if the sum of the face values on all three first color dice is 17 (sum-2 = 15). On the other hand, the player gets two Lanthanides cards if the sum of the face values is 18 (sum-2 = 16). This Lanthanides card can also be played as an element-substitutable card.

The sum of the face values on all three second-colour dice is determined. The player can pick an Actinides card in the position Sum - 2. For example, if sum is 6 + 4 + 4 = 14, the player can pick the element card from position 14 - 2 = 12 (Md). There are only 14 Actinide cells in row 9, so the player does not get an Actinides card if the sum of the face values on all three second-color dice is 17 (sum-2 = 15). On the other hand, the player gets two Actinides cards of the player's choice if the sum of the face values is 18 (sum-2 = 16). This Actinides card can also be played as a group- substitutable card.

Through steps (i) - (x), a player selects a maximum of up to 10 element cards (3 from the first 6 rows, 3 from the 7th row and a maximum of 2 each from the Actinides and Lanthanide groups).

The atomic number (or optionally atomic weight, if so decided at the start of the game) of the card used by the player to form chemical compounds will be used as the score for a given round.
The duration of play is decided at the beginning either (i) by fixing the maximum number of rounds, the winner being the player(s) with highest score at the end of the last round), or (ii) by fixing a pre-set score, the game ending as soon as one player achieves this score. (Alternatively, other criteria acceptable to the team of players may be set before the game starts).

**Embodiment 3: A Beginner Level Active Learning Card Game For Studying the Periodic Table of Chemical Elements**

This embodiment is a game intended for youngsters and/or people who are relatively new to chemistry and the Periodic Table of elements. In this embodiment, a player starts by playing a card from any one of the 18 columns of the table 402. All other players must play cards from the same column in that round, if they have a card from the same column. Otherwise, they are free to play any other card. The player with the highest atomic number from that column wins the round and claims all of the cards played during that round (i.e., in the playing area 404). The next round is started by the winner of the current round, by playing a card of their choice. The game will end when either (i) all cards are consumed, the player with the highest score being the winner, or (ii) a pre-defined score is achieved by a player who then is the winner. As before, a player's score is the sum of the atomic numbers (or, optionally, atomic weight, if so decided at the start of the game) of cards acquired by the player during the game.

**Embodiment 4: A Beginner Level Active Learning Card Game For Studying the Periodic Table of Chemical Elements**

An embodiment will now be described which is a game intended for beginners or intermediate level players who are relatively new to the Periodic Table of elements and chemistry. In this embodiment a player starts by playing a card from any one of the 18 columns of the table 402. The next player plays a card such that the sum of electrons in the outermost or valence shell (second or third outermost shell that is not complete) of all cards in the play area 404 gives 2, 8, 18, 32, or 64. The player who played the card with the highest atomic number will be allowed to choose cards from the playing area 404 such that the sum of outermost or valence shell electrons is 2, 8,
18, 32, or 64. Alternatively, the player in a round can collect the cards as soon as the cards in the playing area 404 meet the condition that the outermost or valence shell electron count sum is 2, 8, 18, 32, or 64, instead of waiting for the round to be over and allowing the player who served the highest value card in the round to choose. After collecting the cards, the player has to play one card again, to continue the game. If the player has no card that would help to meet the above condition (sum of outermost or transition shell electrons is 2, 8, 18, 32, 64), they may play any card of their choice from their collection (hand). The game will be over when either (i) all cards are consumed or (ii) a predetermined score is achieved by a player.

In the following examples, the term "as it happens" applies to a situation in which instantaneous reaction results; for example a decision is made by the player immediately after playing the card to see whether the player can win some cards whereas the term "as it settles" implies that the decision is made at the end of any given round to pick a winner of the round. Thus, a player has to wait until every other player has played the round before knowing who is the winner.

**Card Game Embodiment 5**: Periodic Quest: The Atomic Number Game - As it happens

**Summary**

In each round, each player adds one card from the shuffled deck to their collection and places a card on the table from the player's collection. If the card placed by the player has the highest value (atomic number) among the cards of the same *card type in play* on the table, the player can earn all cards on the table thus far in that round. The subsequent player starts the next round by playing a card of his/her choice (for the *card type*) after adding a card from the shuffled deck to his/her collection. The *card type* of this card is the *card type in play* and a subsequent player can claim all cards in the play area by playing a card with higher value and with *card type* same as *card type in play*. At the end of the round, the player who played the starting card for the round will get (earn) all cards in the play area, if no other player could place a card of *card type in play* and with higher value (atomic number), in that round.
The rounds continue until all cards in the deck and in players' respective hands have been played. The player with the highest sum of the earned card values (atomic numbers), or the player with the maximum number of cards (any card type) earned, wins the game (one or the other of these option to be decided at the beginning of the game).

**Method of Playing**

The general procedure for playing this card game is as follows:

1. One player cuts a well-shuffled deck of cards and deals 5-7 cards to each player, one card at a time, then places the remaining cards face down at the center of the playing area.

2. The same player starts the game by picking a card from the deck in the play area and then placing a card from his/her collection, face up, in the play area. The *card type* of this card is the *card type in play*.

3. The next player in the round, in the clockwise direction, repeats the step 2 above by picking a card from the deck in the play area, adding to his/her collection, and placing a card of his/her choice, face up in the play area.

4. If the card placed by the player is of *card type card type in play* and has the highest value (atomic number) among the cards with *card type as card type in play* in the play area, the player can earn all cards in the play area thus far in that round. If this happens, the subsequent player starts the next round by playing a card of his/her choice (*card type of this card will be the card type in play*) after adding a card from the shuffled deck to his/her collection.

5. At the end of a round, the player who placed the starting card for the round will get (earn) all cards in the play area, if no other player could place a card of same *card type as that of card type in play* and with higher value (atomic number), in that round.

6. The cards acquired (earned) by a player in a round will be set aside by the player as earned cards and will not be used when playing subsequent rounds.
7. The adjacent player on the left of the winner of the round will start the next round by taking a card from the deck and playing a card face up on the table.

8. The game continues until all cards in the deck and in the hands of players are used up.

9. Alternatively, the players may keep a running score based on their "earned" cards and the game may end when a pre-defined score has been achieved by one player.

10. Each player determines his/her score by adding up the atomic numbers (or, optionally, by counting the earned cards, if so decided at the start of the game) from all of the cards that player has earned in the game through different rounds.

11. The player with the highest score is the winner of the game.

12. A player may skip a round by playing a noble element card which has zero value.

13. During any round of the game, a player may "clean up" the round by means of a nuke attack, i.e., by clearly declaring the intention to nuke and playing a radioactive card to reduce the chance of an opponent winning.

14. If a player does a nuke attack in a round, all cards in the playing area will be discarded (no player gets them) at the end of the round, unless a subsequent player in the same round "neutralizes" the nuke attack by playing another radioactive card with higher value (atomic number). Players cannot earn cards in the nuke attacked round by playing a card of matching card type and highest value.

15. A player can reduce the loss by playing a noble element card (if he/she has one) subsequent to someone declaring a nuke attack.

16. Once a nuke attack is declared in a round, any subsequent player can neutralize the nuke attack by playing another radioactive card with a higher value (atomic number) than that used for the nuke attack.

17. If more than one player attempts to neutralize the attack by playing a radioactive card, the player who played a radioactive card to neutralize the attack with the highest value (atomic number) will be the winner of the round.

18. The winner of the round by neutralizing a nuke attack will earn all cards in the play area as the reward.
19. A player who carried out the *nuke* attack will not get any cards in that round whether the attack is neutralized or not. If the attack is not neutralized, the player to the left of last player in the round starts the next round, after removing the cards from the play area (no one gets these cards).

**Embodiment 6: Periodic Quest: The Atomic Number Game - As it settles**

**Summary**

Embodiment 6 is a variation of Embodiment 3.

In each round, each player adds one card from the shuffled deck to their collection and places a card on the table from the player's collection. The *card type* of this card defines the *card type in play* for the round. At the end of the round, the player who played card with highest atomic number that matches the starting *card type (card type in play)* wins the round and claims all cards in play area.

The rounds continue till all cards in the deck and in players' hands are played.

The player with highest sum of the earned card values (atomic numbers) or alternatively the player with maximum number of cards (any card type) earned wins the game (to be decided at the beginning of the game).

**Method of Playing**

The general procedure for playing this card game is as follows:

1. One player cuts a well-shuffled deck of cards and deals 5-7 cards to each player, one card at a time, and places the remaining cards face down at the center of the playing area.

2. The same player starts the game by picking a card from the deck in the play area and then placing a card, face up, on the play area. The *card type* of this card is the *card type in play* for the round.

3. The next player in the round, in the clockwise direction, repeats the step 2 above by picking a card from the deck in the play area, adding to his/her collection, and placing a card of his/her choice, face up in the play area.
4. At the end of the round, the player who played the card with the highest value (atomic number) among the cards of the same card type and with the same Card Type Indicator with which the round has started (card type inplay) is the winner of the round and gets all cards in the playing area.

5. The cards acquired by the winner of a particular round will be set aside by the player as earned cards and will not be used when playing subsequent rounds.

6. The adjacent player on the left to the winner of the round will start the next round by taking a card from the deck and playing a card face up on the table.

7. The game continues until all cards in the deck and in the hands of players are used up.

8. Alternatively, the players may keep a running score based on their "earned" cards and the game may end when a pre-defined score has been achieved by one player.

9. Each player determines his/her score by adding up the atomic numbers (or, optionally, by counting earned cards, if so decided at the start of the game) from all of the cards that player has earned in the game through different rounds.

10. The player with the highest score is the winner of the game.

11. A player may skip a round by playing a noble element card which has zero value.

12. During any round of the game, a player may "clean up" the round by means of a nuke attack, i.e., by clearly declaring the intention to nuke and playing a radioactive card to reduce the chance of an opponent winning.

13. If a player does a nuke attack in a round, all cards in the playing area will be discarded (no player gets them), unless a subsequent player in the same round "neutralizes" the nuke attack by playing another radioactive card with higher atomic number (value). Players cannot earn cards in the nuke attacked round by playing a card of matching card type (matching to the card type inplay) and highest value.

14. A player can reduce the loss by playing a noble element card (if he/she has one) subsequent to someone declaring a nuke attack.
15. Once a nuke attack is declared in a round, any subsequent player can neutralize the nuke attack by playing another radioactive card having a higher atomic number than that used to declare the nuke attack.

16. If more than one player attempt to neutralize the attack by playing a radioactive card, the player who played a radioactive card to neutralize the attack with the highest value (atomic number) will be the winner of the round.

17. The winner of the round by neutralizing a nuke attack will earn all cards in the play area as the reward.

18. A player who carried out the nuke attack will not get any cards in that round whether the attack is neutralized or not. If the attack is not neutralized, the player on the left of the last player in the round will start the next round, after removing all cards (no one gets these cards) from the play area.

Embodiment 7: Periodic Quest: Primordial Soup - As it happens

Summary

Sequentially, each player adds one card from the shuffled deck to their collection and places a card on the table from the player's collection. The player who just played a card then tries to use some or all cards on the table to form chemical compound(s), and earns all cards used in the compound formation. A card in the play area can be used only once to form chemical compound. The process continues until all cards in the deck and in players' respective hands are played. The player with highest sum of the earned card values (atomic numbers) or alternatively the player with maximum number of cards (any card type) earned wins the game (to be decided at the beginning of the game).

Method of Playing

The general procedure for playing this card game is as follows:

1. One player cuts a well-shuffled deck of cards and deals 5-7 cards to each player, one card at a time, and places the remaining cards face down at the center of the playing area.
2. The same player starts the game by picking a card from the deck in the play area and then placing a card, face up, on the play area. If the player can make chemical compound(s) from the cards present face up in the playing area, the player loudly states the compound name and earns the cards used for compound formation, adding the cards to the player's earned cards collection. A card in the play area can be used only once to form chemical compound.

3. In a round, step 2 above is repeated by each subsequent player in the clockwise direction, by adding a card from the deck to his/her collection, placing a card face up in the playing area and attempting to form chemical compound(s) from the cards present in the playing area.

4. Each player, immediately after playing the card, goes through all of the cards in the playing area to create as many chemical compounds as possible and acquires the cards that are used to form chemical compounds as "earned" cards. To win the cards the player must clearly state the name of the chemical compound formed. The name and the chemical composition of the compound formed by the player may be substantiated by some acceptable reference, if challenged by another player. When making these compounds, the player may use a card only once. The objective is to earn as many cards as possible with high values (the atomic numbers) in each round, to maximize the score.

5. The cards acquired by a player in a particular round will be set aside by the player as earned cards and will not be used in subsequent rounds by the player.

6. The cards that are not used for compound formation in a round will be left in the playing area and will be made available for compound formation for subsequent players and subsequent rounds.

7. The game continues until all cards in the deck and in the hands of players are used up.

8. Alternatively, the players may keep a running total of the atomic numbers (card values) of their "earned" cards and the game may end when a pre-defined score has been achieved by a player.

9. Each player determines his/her score by adding up the atomic numbers (card values) for all cards that player has earned and set aside.
10. The player with the highest score is the winner of the game.
11. A player may skip a round by playing a noble element card which has zero value. The player will not be able to earn any cards in that round (not allowed to make chemical compounds using cards in the play area).
12. During any round of the game, a player may "clean up" the board by means of a nuke attack, i.e., by playing a radioactive card to reduce the chance of an opponent winning.
13. If a player does a nuke attack in a round, all cards in the playing area will be discarded (no player gets them) at the end of the round, unless a subsequent player in the same round "neutralizes" the nuke attack by playing another radioactive card with higher value (atomic number). Players can no more earn cards through compound formation for that round.
14. A player can reduce the loss by playing a noble card (if he/she has one) subsequent to someone declaring a nuke attack.
15. Once a nuke attack is declared in a round, any subsequent player can neutralize the nuke attack by playing another radioactive card with a higher value (atomic number) than that used for the nuke attack.
16. If more than one player attempt to neutralize the attack by playing a radioactive card, in a round, the player who played a radioactive card (to neutralize the nuke attack) with the highest value (atomic number) will be the winner of the round.
17. The winner of the round by neutralizing a nuke attack will earn all cards in play area as the reward (no compound formation).
18. A player who carried out the nuke attack will not get any cards in that round whether the attack is neutralized or not.
19. If the attack is not neutralized, all cards will be removed from the playing area, at the end of the round. The player to the left of the last player in the round will start new round.
20. A player can use column-substitutable, element-substitutable or group-substitutable cards to form a maximum number of distinct chemical compounds and thus collect maximum number of cards.
21. A player cannot make compounds with just Actinide and Lanthanide cards alone, if all cards used for compound formation are used in "substitutable" roles (Lanthanides as element-substitutable and Actinides as group-substitutable).

Embodyment 8: Periodic Quest: Primordial Soup - As it settles

Summary

Embodiment 8 is a generalized form of embodiment 1.

Sequentially, each player adds one card from the shuffled deck to his/her collection and places a card on the table from the player's collection. The card type of this card defines the card type in play for the round. At the end of the round, the player who played card with highest atomic number (value) that matches the starting card type (card type in play) gets a chance to form chemical compounds and win those cards used in the formation of the compounds. The rounds continue till all cards in the deck and in players' hands are played. The player with highest sum of the earned card values (atomic numbers) or alternatively the player with maximum number of cards (any card type) earned wins the game (to be decided at the beginning of the game).

Method of Playing

The general procedure for playing this card game is as follows:

1. One player cuts a well-shuffled deck of cards and deals 5-7 cards to each player, one card at a time, and places the remaining cards face down at the center of the playing area.

2. The same player starts the game by picking a card from the deck in the play area and then placing a card, face up, on the play area. The card type of this card defines the card type in play for the round.

3. In a round, step 2 above is repeated by each subsequent player in the clockwise direction, by adding a card from the deck to his/her collection, placing a card face up in the playing area.

4. At the end of the round, the player who played the card with the highest value (atomic number) and with the same Card Type Indicator with which the round
started *(card type in play)* for the round, attempts to make chemical compound(s)
using all cards in the playing area. To win the cards the player must clearly state
the name of the chemical compound formed. The name and the chemical
composition of the compound formed by the player must be substantiated by
some acceptable reference, if needed.

5. The winner of the round can earn all cards used in the formation of chemical
compounds from that round. These cards will be set aside by the winner as *earned*
cards and will not be used when playing subsequent rounds by the player.

6. The adjacent player on the left to the winner of the round will start the next
round by adding a new card from the deck and playing a card, face up on the
table and continues the game as described above.

7. This game continues until all cards in the deck and in the hands of players are
used up.

8. Alternatively, the players may keep a running score based on their "earned"
cards and the game may end when a pre-defined score has been achieved by one
player.

9. Each player determines his/her score by adding up the atomic numbers *(or,
optionally, by counting the earned cards, if so decided at the start of the game)*
from all of the cards that player has earned and set aside.

10. The player with the highest score is the winner of the game.

11. A player may skip a round by playing a noble element card which has zero
value.

12. During any round of the game, a player may "clean up" the round by means
of a *nuke* attack, i.e., by clearly declaring the intention to *nuke* and playing a
*radioactive* card to reduce the chance of an opponent winning.

13. If a player does a *nuke* attack in a round, all cards in the playing area will be
discarded (no player gets them), unless a subsequent player in the same round
"neutralizes" the *nuke* attack by playing another *radioactive* card with higher
atomic number. Players can no more earn cards through compound formation for
that round.
14. A player can reduce the loss by playing a noble card (if he/she has one) subsequent to someone declaring a nuke attack.

15. Once a nuke attack is declared in a round, any subsequent player can neutralize the nuke attack by playing another radioactive card having a higher atomic number than that used to declare the nuke attack.

16. If more than one player attempt to neutralize the attack by playing a radioactive card, the player who played a radioactive card (to neutralize the attack) with the highest value (atomic number) will be the winner of the round.

17. The player who neutralized a nuke attack will earn all cards in the play area as the reward.

18. A player who carried out the nuke attack will not get any cards in that round whether the attack is neutralized or not. If the attack is not neutralized, the player to the left of the last player in the round will remove the cards from play area (no one gets the cards) and start a new round.

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**Embodiment 9**: Periodic Quest: The Shell Game - As it happens

**Summary**

This game is intended for players who are relatively new to the Periodic Table of elements and Chemistry and introduce them to the atomic shell structure. In each round, each player adds one card from the shuffled deck to his/her collection and places a card on the table from the player's collection. After placing the card in the play area, the player can earn groups of cards from the play area thus far in the round. To earn a group of cards, the cards in a group should meet the condition that the sum of outermost or valence shell electron count of individual cards from the group is 2, 8, 18, 32, or 64. A card in the play area can be used only in one group. The rounds continue till all cards in the deck and in players' hands are played. The player with highest sum of the earned card values (atomic numbers) or alternatively the player with maximum number of cards (any card type) earned wins the game (to be decided at the beginning of the game).
Method of Playing

The general procedure for playing this card game is as follows:

1. One player cuts a well-shuffled deck of cards and deals 5-7 cards to each player, one card at a time, and places the remaining cards face down at the center of the playing area.

2. The same player starts the game by picking a card from the deck in the play area and then placing a card from his/her collection, face up, in the play area.

3. The next player in the round, in the clockwise direction, repeats the step 2 above by picking a card from the deck in the play area, adding to his/her collection, and placing a card of his/her choice, face up in the play area.

4. After placing the card in the play area, the player can earn group(s) of cards from the play area thus far in the round, as earned cards. To earn a group of cards, the cards in a group should meet the condition that the sum of outermost or valence shell electron count of individual cards from the group is 2, 8, 18, 32, or 64.

5. A card in the play area can be used only in one group.

6. The subsequent player starts the next round by playing a card of his/her choice after adding a card from the shuffled deck to his/her collection.

7. If the player has no card that would help to meet the above condition (sum of outermost or transition shell electrons is 2, 8, 18, 32, 64), he/she may play any card of their choice from his/her collection in hand.

8. The cards acquired by a player in a round will be set aside by the player as earned cards and will not be used when playing subsequent rounds.

9. The game continues until all cards in the deck and in the hands of players are used up.

10. Alternatively, the players may keep a running score based on their "earned" cards and the game may end when a pre-defined score has been achieved by one player.

11. Each player determines his/her score by adding up the atomic numbers (or, optionally, by counting the earned cards, if so decided at the start of the game) from all of the cards that player has earned in the game through different rounds.
12. The player with the highest score is the winner of the game.
13. A player may skip a round by playing a noble element card which has zero value.
14. During any round of the game, a player may "clean up" the round by means of a nuke attack, i.e., by clearly declaring the intention to nuke and playing a radioactive card to reduce the chance of an opponent winning.
15. If a player does a nuke attack in a round, all cards in the playing area will be discarded (no player gets them) at the end of the round, unless a subsequent player in the same round "neutralizes" the nuke attack by playing another radioactive card with higher value (atomic number). Players cannot earn cards in the nuke attacked round by making groups of cards (that meet the condition that the sum of outermost or valence shell electron count of individual cards from the group is 2, 8, 18, 32, or 64) from the play area.
16. A player can reduce the loss by playing a noble element card (if he/she has one) subsequent to someone declaring a nuke attack.
17. Once a nuke attack is declared in a round, any subsequent player can neutralize the nuke attack by playing another radioactive card with a higher value (atomic number) than that used for the nuke attack.
18. If more than one player attempt to neutralize the attack by playing a radioactive card, the player who played a radioactive card (to neutralize the attack) with the highest value (atomic number) will be the winner of the round.
19. The winner of the round by neutralizing a nuke attack will earn all cards in the play area as the reward.
20. A player who carried out the nuke attack will not get any cards in that round whether the attack is neutralized or not. If the attack is not neutralized, the player to the left of the last player in the round will remove all cards from the play area (no one gets them) and starts the new round.

**Embodiment 10: Periodic Quest: The Shell Game - As it settles**

**Summary**

Embodiment 10 is a variation of embodiment 4.
This game is intended for players who are relatively new to the Periodic Table of elements and Chemistry and introduces them to the atomic shell structure. In each round, each player adds one card from the shuffled deck to his/her collection and places a card on the table from the player's collection. The card type of this card defines the card type in play for the round. At the end of the round, the player who played card with highest atomic number (value) that matches the starting card type gets a chance to earn groups of cards from the play area. To earn a group of cards, the cards in a group should meet the condition that the sum of outermost or valence shell electron count of individual cards from the group is 2, 8, 18, 32, or 64. A card in the play area can be used only in one group. The rounds continue till all cards in the deck and in players' hands are played. The player with highest sum of the earned card values (atomic numbers) or alternatively the player with maximum number of cards (any card type) earned wins the game (to be decided at the beginning of the game).

Method of Playing

1. One player cuts a well-shuffled deck of cards and deals 5-7 cards to each player, one card at a time, and places the remaining cards face down at the center of the playing area.

2. The same player starts the game by picking a card from the deck in the play area and then placing a card from his/her collection, face up, in the play area. The Card Type of this card defines the Card Type in play for the round.

3. The next player in the round, in the clockwise direction, repeats the step 2 above by picking a card from the deck in the play area, adding to his/her collection, and placing a card of his/her choice, face up in the play area.

4. At the end of the round, the player who played the card with the highest value (atomic number) and with the card type as card type in play for the round (card type with which the round started), can earn group(s) of cards from the play area in the round, as earned cards. To earn a group of cards, the cards in a group should meet the condition that the sum of outermost or valence shell electron count of individual cards from the group is 2, 8, 18, 32, or 64.
5. A card in the play area can be used only in one group.
6. The adjacent player on the left to the winner of the round will start the next round by adding a new card from the deck and playing a card, face up on the table and continues the game as described above.
7. If the player has no card that would help to meet the above condition (sum of outermost or transition shell electrons is 2, 8, 18, 32, 64), he/she may play any card of his/her choice from his/her collection in hand.
8. The cards acquired by a player in a round will be set aside by the player as earned cards and will not be used when playing subsequent rounds.
9. The game continues until all cards in the deck and in the hands of players are used up.
10. Alternatively, the players may keep a running score based on their "earned" cards and the game may end when a pre-defined score has been achieved by one player.
11. Each player determines his/her score by adding up the atomic numbers (or, optionally, by counting the earned cards, if so decided at the start of the game) from all of the cards that player has earned in the game through different rounds.
12. The player with the highest score is the winner of the game.
13. A player may skip a round by playing a noble element card which has zero value.
14. During any round of the game, a player may "clean up" the round by means of a nuke attack, i.e., by clearly declaring the intention to nuke and playing a radioactive card to reduce the chance of an opponent winning.
15. If a player does a nuke attack in a round, all cards in the playing area will be discarded (no player gets them) at the end of the round, unless a subsequent player in the same round "neutralizes" the nuke attack by playing another radioactive card with higher value (atomic number). Players cannot earn cards in the nuke attacked round by making groups of cards (that meet the condition that the sum of outermost or valence shell electron count of individual cards from the group is 2, 8, 18, 32, or 64) from the play area.
16. A player can reduce the loss by playing a noble card (if he/she has one) subsequent to someone declaring a *nuke* attack.

17. Once a *nuke* attack is declared in a round, any subsequent player can neutralize the *nuke* attack by playing another *radioactive* card with a higher value (atomic number) than that used for the *nuke* attack.

18. If more than one player attempts to neutralize the attack by playing a *radioactive card*, the player who played a *radioactive card* (to neutralize the attack) with the highest value (atomic number) will be the winner of the round.

19. The winner of the round by neutralizing a *nuke* attack can earn all cards in the play area as the reward.

20. A player who carried out the *nuke* attack will not get any cards in that round whether the attack is neutralized or not. The player left to the last player of the round will clean up the cards in the play area (no one gets the cards) and starts the new round.

**Embodiment 11: Periodic Quest: The Explorer Board Game**

**Summary**

The explorer board game takes players through the periodic table and introduces them to various elements and encourages them to challenge their opponents in the understanding of properties of different elements. Each player advances through the Periodic Table of Elements on the board on their side, by rolling a die, and earning cards along the way through the positions occupied on the board and through winning "challenges". The player with highest sum of the earned card values (atomic numbers) or alternatively the player with maximum number of cards (any card type) earned wins the game (to be decided at the beginning of the game).

**Method of Playing**

The general procedure for playing this board game is as follows:
1. This is a board game that can be played between up to four players (actual or virtual) using the Periodic Quest Game Board, a single set of Periodic Quest Playing Cards, a Die and one peg per each player.

2. Each player uses the Periodic Table on the board for traversing the peg based on the die value.

3. The cards are placed vertically, at the center of the game board in a special card holder, preferably arranged in sequential order based on the card value from 1-118.

4. One player starts the game by throwing the die. The player advances his/her peg along the Periodic Table Column from its current position (0 to start with) by the number identified by the face of the die and picks up the corresponding Card, as the earned card for the round. For example, the game starts with column 1 and if the face value of the die is 3, peg will take the third cell in column 1 (11 - Na); after reaching the last cell in column 1 (87 - Fr), the peg proceeds to Column 2 cell 1 (4 - Be). Similarly, after reaching the last cell in Column 2 (88 - Ra), the peg proceeds to Column 3 cell 1 (21 - Sc) and so on. Optionally, the player could be challenged to state a fact about the element identified by the card before advancing to the new cell on the board.

5. Each subsequent player on the left of the current player (clockwise direction) takes turn and throws the die and advances his/her peg along the Periodic Table Column from its current position (0 to start with) by the number identified by the face of the die. The player earns the corresponding card, if it is not already claimed by another player.

6. In column 3, the player moves from element 89 (Ac) to element 58 (Ce), and then to element 90 (Th) before proceeding to element 22 (Ti) in column 4. Similarly in column 4, the player moves from element 104 (Rf) to element 59 (Pr) and then to element 91 (Pa) before proceeding to element 23 (V) in column 5. This traversal pattern continues for all columns up to and including column 16.

7. This game continues till a player reaches or crosses the last position (118).
8. Alternatively, the players may keep a running score based on their "earned" cards and the game may end when a pre-defined score has been achieved by one player.

9. Each player determines his/her score by adding up the atomic numbers (or, optionally, by counting the earned cards, if so decided at the start of the game) from all of the cards that player has earned in the game through different rounds.

10. During the game, if a player ('player 2') lands in a position already occupied by another player ('player 1')'s peg, the 'player 2' has two different options.
   a. Option 1: move into the position without claiming the card associated with that position (cell number). With this option, the round continues by the next player on the left to the 'player 2' throwing the die, without going through the steps below (steps 11 to 13 inclusive).
   b. Option 2: 'player 2' challenges the 'player 1' to handover the card associated with that position. Irrespective of the outcome of the challenge (who wins/looses the challenge), the players get to keep their peg positions.

11. 'player 2' makes a challenge (Option 10 b. above) by placing one card (from his/her earned cards) face down on the board and challenging the 'player 1' to beat a specific character of the element's (represented by the card) property. 'player 2' could challenge 'player 1' to place a card with highest or lowest value (among the cards that are placed as part of the challenge) for a chosen property such as atomic weight, atomic number, density, boiling point, abundance (%) on earth abundance in the universe, year of discovery. Some of these properties are shown on the cards. The players could choose to refer any authentic source of information to include additional properties into the challenge, as decided in the beginning of the game.

12. 'player 1' can choose to skip the challenge by handing over the card in the contested position to 'player 2'. Alternatively, 'player 1' could take up the challenge by placing one card from his/her earned cards. Once the challenge is
declared (by 'player 2') and accepted (by 'player 1'), any other player can choose to join the challenge by placing a card face down in the playing area.

13. Once all participants of the current challenge in the round have placed their cards, all players open up the cards and decide the winner of the challenge. The winner of the challenge gets the card associated with contested position. Optionally, the winner of the challenge also gets the cards placed by all participants of the current challenge.

**Embodyment 12: Periodic Quest: The Challenger Board Game**

**Summary**

Embodiment 12 is a variation of embodied 2.

This board game is the most complex Periodic Quest game. It can be played between two or more players using a set of Periodic Quest Game Board, a single set of Periodic Quest cards, and 6 dice. There are two sets of 3 dice; dice within each set are of identical color and shape. Each player gathers cards from the Periodic Table of Elements by throwing dice and strategically mapping the face values of the dice. These cards are then used to form chemical compounds. The cards used to form compounds are claimed by the player as earned cards and are used to calculate his/her score. The player with highest sum of the earned card values (atomic numbers) or alternatively the player with maximum number of cards (any card type) earned wins the game (to be decided at the beginning of the game), at the end of a pre-defined number of rounds.

**Method of Playing**

The general procedure for playing this board game is as follows:

1. One player starts the game by throwing a set of six dice of two kinds, say 3 black and 3 white.
2. The face values of the dice are used to select the element cards from the Periodic Table of Elements, by following the rules described in the section "To use Dice' face values in locating cards:" below.
3. Once the cards are collected, the player attempts to form chemical
compound(s) using these cards. A card can be used only once (one chemical
compound) while forming chemical compounds. The player must clearly state
the name of the chemical compound formed. The name and the chemical
composition of the compound formed by the player must be substantiated by
some acceptable reference, if needed.

4. The player calculates his/her score for the round by adding up the card value
(atomic number) (or, optionally, by counting the earned cards, if so decided at
the start of the game) for all cards used in the formation of chemical
compounds from this collected cards. The cards will be put back to the
common deck.

5. Each subsequent player on the left of the current player (clockwise direction)
takes turn and throws the dice and tries to earn cards in that round.

6. Each player determines his/her score by adding up the scores for individual
rounds, for the current game.

7. The game continues for a fixed number of rounds decided at the start of the
game.

8. Alternatively, the players may keep a running total of the atomic numbers (or,
optionally, by counting the earned cards, if so decided at the start of the
game) for each round and the game may end when a pre-defined score has
been achieved by one player.

9. The player with highest cumulative score is the winner of the game.

**How To use face values of dice in locating cards:**

The face values of the dice are used to pick the element cards from the Periodic
Table of Elements, as follows:

a) The player rolls the set of six dice on the game board. The face value of each
die could be a number from 1 to 6 (including both).
b) The player makes 3 pairs of dice each pair consists of one white and one black die. The face values of the die guide the player in identifying the right pair, as described below.

c) Row 1 is row starting with element card of value 1 (atomic number 1) - H. Row 2 starts with element card Li of atomic no. 3 while Row 3 starts with element card Na with atomic no. 11. Row 4 starts with element card K with atomic no. 19 and Row 5 starts with element card Rb with atomic number 37. Row 6 starts with element card Cs with atomic number 55 and Row 7 starts with element card Fr with atomic number 87.

d) A row die and a column die together represent a cell in the Periodic Table of Elements and therefore an element card.

e) In each round, the player has to choose the color that represents the column and the color that represents the row. The player can choose this after throwing the dice in his/her turn for the round. Once this decision is made, it should be applied to all three pairs; for e.g. player cannot choose black for row in pair 1 and black for column in pair 2, in a given round.

f) Once the color is chosen for the round, the player has to identify 'first pair', 'second pair' and 'third pair' of dice for the given round.

g) For the 'first pair', the face value of the column die represents columns 1 to 6 in the Periodic Table.

h) For the 'second pair', the face value of the column die plus six (+ 6) denotes a column in the periodic table. Hence, this column die will represent one of columns 7 to 12 (inclusive) in the Periodic Table.

i) For the 'third pair', the face value of the column die plus twelve (+ 12) denotes a column in the periodic table. Hence, this column die will represent one of columns 13 to 18 (inclusive) in the Periodic Table.

Thus, the (three) column dice identify the three segments in the periodic table, covering all 18 columns in the Periodic Table,

j) The face value of the row die in each of these pairs represents a row position in the Periodic Table.
k) The player picks element cards (from the deck of cards in the common playing area) located in the Periodic Table by the column and row values, defined by the face values of these three pairs of dice. The player may use one of the Periodic Tables on the game board to identify the card based on the column, row values identified by the dice. If the (row, column) values locate an empty cell (location outside) in Periodic Table of Elements, the player will not get a card for this location.

l) The player also picks a card from the seventh row such that the 7th row column number is the face value of the row die from the first pair.

m) The player picks a second card from the seventh row such that the 7th row column number = \(6 + \text{face value of row die from the second pair}\).

n) The player also picks a third card from the seventh row such that the 7th row column number = \(12 + \text{face value of row die from the third pair}\).

o) The sum of the face values on all three column dice is determined as 'Sum-col'. The player can pick a Lanthanide card (an element from Lanthanides series) of Periodic Table in the position 'Sum-col' - 2. For example, if the sum is 6 + 1 + 1 = 8, the player can pick the element card from position 8 - 2 = 6 (Eu).

p) There are only fourteen Lanthanide cells, in the periodic table; so the player does not get a Lanthanide card if the sum of the face values on all three column dice is 17 ('Sum-col' - 2 = 15). On the other hand, the player gets two Lanthanide cards of players choice if the sum of the face values of the column dice is 18 ('Sum-col' - 2 = 16). Note that the Lanthanide card can also be played as an element-substitutable card.

q) The sum of the face values on all three row dice is determined as 'Sum-row'. The player can pick an Actinide card (an element from Actinides series) from the Periodic Table, in the position 'Sum-row' - 2. For example, if 'Sum-row' is 6 + 4 + 4 = 14, the player can pick the element card from position 14 - 2 = 12 (Md) in the Actinides series.

r) There are only 14 Actinide cells in row 9; so the player does not get an Actinide card if the sum of the face values on all three row color dice is 17
('Sum-row'-2 = 15). On the other hand, the player gets two Actinides cards of the player's choice if the sum of the face values is 18 ('Sum-row' -2 = 16). Note that, the Actinides card can also be played as a group-substitutable card, s) Through steps i) to q) above, a player selects a maximum of up to 10 element cards (3 from the first 6 rows, 3 from the 7th row and a maximum of 2 each from the Actinides and Lanthanides groups), in each round.

**Embodiment 13:** Periodic Quest: Rummy Card Game

Two or more players could play Periodic Quest Chemistry Rummy game by following the steps described below:

1. Shuffle cards, cut the cards.
2. Distribute 14 cards to each player, one at a time; keep the rest of the cards in a deck on table.
3. Game starts by the first player picking a card from the deck and placing one face up in the play area.
4. The player to the left picks either the most recent face up card on the table or a card from the top of the deck and place a card face up on the table
5. The round continues till a player places a card face down on the table to claim victory. The winning player will have all of his/her cards belonging to set(s) of 4 or more cards.

Cards in each set either are of the same card type or belong to the same row with consecutive card values (atomic numbers).

A card can belong to only one set.

The Noble element cards (card type N) can be used as joker cards, and can take any position in a set, to represent a card in the set, to complete the set

The winner will have Jokers (card type N) as the leftover cards after forming the sets of 4 or more cards.
PLAYING MEDIA

Card games embodying the specified aspects of the invention may employ physical media (such as paper, cardboard or plastic cards) or electronic media, such as a personal computer having any suitable operating system, a gaming console (examples include but are not limited to Sony Playstation™, Microsoft Xbox360™ and Nintendo Wii™) or a hand-held personal communication/entertainment device (examples including, but not limited to cell phones, IPods™, Blackberries™).

A computer-based or electronic media version of the learning system or educational game may be played in a networked environment among multiple players located at different physical locations across the network. The present invention is well suited for being played using so-called "siftable cubes" as disclosed in US Published Patent Application No. 20090273560, the contents of which are incorporated herein by reference, and at website http://tacolab.com/projects/Siftables, http://sifteo.com/).

Embodiments of the invention can be used by a single player, perhaps as part of self-phased learning or training, using a suitably-programmed personal computer or (electronic media or gaming console instead of another player.

The above-described embodiments of the invention help the player(s) not only to memorize the chemical elements listed in the Periodic Table of Chemical elements but also the characteristics which determine the group, column or row in which they are located and the characteristics which lead to them being combined into various compounds. This is achieved using the information depicted in the cards shown, by way of example, in Figures 1A-ID. It is envisaged, however, that the games could be played with cards holding additional information, particularly cards of the kind illustrated in Figures 2A-2D and Figures 3A and 3B, which are examples of cards disclosed in our above-referenced co-pending United States Provisional patent application number 61/297,567. The board game disclosed therein involves questions and answers about the learning modules on the cards so as to structure the learning process whereas, when the same or similar cards are used with embodiments of the present invention, the learning of the contents of the cards (Figs. 2A-2D) would be incidental during game play.
An advantage of embodiments of the present invention which employ the relatively facile concepts of "column-substitutable", "element-substitutable" and "group-substitutable" cards to group the 118 elements represented on the Periodic Table of Chemical Elements is that, in contrast to games disclosed in the prior art, they do not need "made-up" cards with no meaning in the domain of chemistry.

Advantageously, preferred embodiments of the present invention are based on the complete set of chemical elements known to mankind that are represented in the Periodic Table of Chemical Elements, whether naturally occurring, artificially created or predicted.

During the course of game play, the players learn aspects of known elements presented in the Periodic Table of Chemical Elements, such as the atomic weight, atomic number, name and symbol, the position in the Periodic Table of Chemical Elements and what the position means, and/or the valence electron shell structure, simply by exposure to these aspects while playing the game. In addition, like a child building a language vocabulary through word games, the players will be exposed to several chemical compounds through the game. By repeatedly playing the game, and competing and interacting, the players will be exposed to, and may acquire, knowledge about hundreds of existing known chemical compounds, radioactive elements and noble gases.

It should be noted that the use of the game board 400 in the foregoing embodiments of the invention is a matter of convenience only. The game(s) could be played without using such a game board, the cards being placed upon any suitable surface. When necessary, reference to the Periodic Table of Chemical Elements could be made to a copy of it in a text book, on a wall chart, on a computer screen, and so on.

It should also be noted that the information on the playing cards shown in Figures 12A-12D, 13A and 13B, and the other cards in the set, could be derived to represent a predetermined corpus of knowledge using the procedures described with respect to Figure 11 and the cards shown in Figures 2A-2D, 5A-5D and 6A-6D, though that is not essential.

At present, the Periodic Table comprises chemical elements 1-118 (103 naturally occurring and the remainder artificial. It should be noted that, until very
recently, a theoretical element 117 had been predicted but had not been discovered. It should be understood that the use of the term Periodic Table herein is intended to embrace a periodic tables of chemical elements that are naturally occurring, artificial or theoretical but predicted.

INDUSTRIAL APPLICABILITY

Active learning systems or educational board and/or card games embodying the invention facilitate the learning of a variety of subjects, especially the vast field of chemistry encapsulated by the Periodic Table of Chemical Elements. Advantageously, embodiments of the present invention can be used by players at all skill levels, from beginners with no knowledge of chemistry to those players with expert knowledge in chemistry.

Although preferred embodiments of the invention have been described and illustrated in detail, it is to be clearly understood that the same are by way of illustration and example only and not to be taken as delimiting the combinations of features necessary to implement the invention, the scope of the present invention being limited only by the appended claims.
CITATION LIST

PATENT LITERATURE
EP 0023687
US 7490834
US 20080284104
US 20090273560

NON-PATENT LITERATURE
CLAIMS

1. An active learning system for use by at least one participant, the system comprising:
   a plurality of learning modules whose contents together make up a predetermined corpus of knowledge to be learned,
   a corresponding plurality of sets of questions and answers, each question set relating to a corresponding one of the learning modules, and
   rules prescribing a sequence of events constituting a learning session having a learning session start and a learning session finish, said events comprising, for said at least one participant,
   selecting at least some of said learning modules individually and successively,
   for each selected learning module selecting one of the set of related questions for the participant to answer, and
   recording progress of said at least one participant from a learning session start towards a learning session finish according to whether or not said at least one participant answers the selected ones of the set of related questions correctly,
   selecting at least some of said learning modules individually and successively,
   for each selected learning module selecting one of the set of related questions for the participant to answer, and
   recording progress of said at least one participant from a learning session start towards a learning session finish according to whether or not said at least one participant answers the selected ones of the set of related questions correctly.

2. An active learning system according to claim 1, wherein said progress is further determined by chance selection means, for example, one or more dice or other random-number generating means.

3. An active learning system according to claim 2, wherein the chance selection means determines not only the selected one of the questions but also the degree of
progress to be made by the participant if the participant answers the selected question correctly.

4. An active learning system according to claim 1, 2 or 3, wherein the rules prescribe for the participant to have the option of answering a different question instead of the question selected from said corresponding set of questions relating to the selected learning module.

5. An active learning system according to claim 1, 2, 3 or 4, wherein said progress is tracked by means of a progress chart demarcated according to the corpus of knowledge, the system further comprising a suitable marker for indicating the participant's current position between said starting and finishing points of the progress chart.

6. An active learning system according to claim 5, wherein said progress chart comprises a series of cells defining a path to be traversed by the participant's marker between the starting and finishing points.

7. An active learning system according to claim 6, wherein the plurality of learning modules and corresponding set of related questions and answers are equal in number to said plurality of cells of the progress chart and each learning module carries an identifier linking the learning module with a respective one of the cells, and/or vice versa.

8. An active learning system according to claim 6 or 7, wherein said series of cells are sub-divided into groups and the progress chart further comprises, for each group, one of a plurality of spots for receiving markers to indicate traversal of the group of cells.

9. An active learning system according to claim 8, wherein said progress chart comprises at least one depiction of the Periodic Table of Chemical Elements, each cell of the progress chart corresponding to a respective one of the chemical elements, the
plurality of learning modules being equal in number to the chemical elements and identified by the atomic number of a respective one of said chemical elements in said table.

10. An active learning system according to any one of claims 1 to 9, further comprising at least one set of playing cards corresponding to said plurality of learning modules, each playing card bearing a respective one of said learning modules and the corresponding set of related questions and answers.

11. An active learning system according to claim 10, wherein the playing cards are physical cards, each playing card having the respective learning module on one (reverse) side and the corresponding set of questions and answers on its other (obverse) side.

12. An active learning system according to any one of claims 5 to 10, wherein the progress chart is electronic and the learning modules and related questions and answers are depicted electronically as playing cards.

13. An active learning system according to any one of claims 1 to 12, comprising a plurality of said sets of learning modules, the content of at least one of said sets of learning modules differing from the content of the other set or sets of learning modules.

14. An active learning system according to any one of claims 5 to 10, wherein one progress chart is configured for sharing by two or more participants, each participant using markers that can be distinguished from markers of the or each other participant.

15. Apparatus for use by participants during an active learning session, the apparatus comprising a progress chart, a set of rules for the participants to follow when conducting the active learning session and, for each participant, a set of learning modules and a marker, the progress chart showing, for each participant, a path between a learning session start and a learning session finish, the path to be traversed by the marker of that
participant as the session progresses, the set of learning modules together making up the corpus of knowledge to be learned by that participant, each learning module having associated therewith a set of questions about the corresponding learning module and either the answer to each of the questions or a link to the answer, the rules prescribing a sequence of events constituting a learning session having a learning session start and a learning session finish, said events comprising, for said at least one participant.

16. Apparatus according to claim 15, further comprising chance selection means, for example, one or more dice or other random-number generating means, said rules prescribing use of said chance selection means by said at least one participant to select said learning module.

17. Apparatus according to claim 16, wherein the rules further prescribe for use of said chance selection means by said participant to determine the degree of progress to be made by the participant if the participant answers the posed question correctly.

18. Apparatus according to claim 15, 16 or 17, wherein the rules prescribe for the participant to have the option of answering a different question instead of the question selected from said corresponding set of questions relating to the selected learning module.

19. Apparatus according to claim 15, 16, 17 or 18, wherein said progress chart is demarcated according to the corpus of knowledge.

20. Apparatus according to claim 19, wherein said progress chart comprises a series of cells defining a path to be traversed by the marker between the starting and finishing points.

21. Apparatus according to claim 20, wherein the plurality of learning modules are equal in number to said plurality of cells of the progress chart and each learning module carries an identifier linking the learning module with a respective one of the cells.
22. Apparatus according to claim 20 or 22, wherein said series of cells are subdivided into groups, the system further comprises, for each participant, an additional marker for each group, and the progress chart further comprises, for each group, a spot for receiving said additional marker to indicate traversal of the corresponding group of cells.

23. Apparatus according to claim 22, wherein said progress chart comprises a depiction of the Periodic Table of Chemical Elements, each cell of the progress chart corresponding to a respective one of the chemical elements, the plurality of learning modules being equal in number to the chemical elements, each learning module being identified by the atomic number of a respective one of said chemical elements in said table.

24. Apparatus according to any one of claims 15 to 23, further comprising at least one set of playing cards corresponding to said plurality of learning modules, each playing card bearing a respective one of said learning modules and the corresponding set of related questions and answers or pointers to said answers.

25. Apparatus according to claim 24, wherein the playing cards are physical cards, each playing card having the respective learning module on one (reverse) side and the corresponding set of questions on its other (obverse) side.

26. Apparatus according to any one of claims 15 to 24, wherein the progress chart is electronic and the learning modules and related questions and answers are depicted electronically as playing cards.

27. Apparatus according to any one of claims 15 to 26, comprising a plurality of said sets of learning modules, the content of at least one of said sets of learning modules differing from the content of the other set or sets of learning modules.
28. An active learning system according to any one of claims 15 to 27, wherein one progress chart is configured for sharing by two or more participants, each participant using markers that can be distinguished from markers of the or each other participant.

29. A method of creating an active learning system comprising the steps of:
   (i) identifying a distinct source of information;
   (ii) parsing the information into a plurality of learning modules together making up a corpus of knowledge to be learned, for example by traversing the source information to extract learning modules or by copying page-by-page into respective learning modules;
   (iii) for each of the learning modules, devising a set of related questions to be answered by a participant during a learning session and a corresponding set of answers to the questions;
   (iv) setting out rules prescribing a sequence of events constituting a learning session having a learning session start and a learning session finish,
   (v) preparing a progress chart for indicating progress of the corresponding participant during said session, said progress chart having a path between a start point and a finish point corresponding to said learning session start and finish, respectively, said path comprising a plurality of steps equal in number to said learning modules, each learning module having an identifier linking said learning module to a respective one of the steps;
   said events comprising, for at least one participant,
   selecting at least some of said learning modules individually and successively,
   for each selected learning module selecting one of the set of related questions for the participant to answer, and
   recording progress of said at least one participant from a learning session start towards a learning session finish according to whether or not said at least one participant answers the selected ones of the set of related questions correctly.

30. A method according to claim 29, further comprising
(vi) preparing a set of cards on physical or electronic media, each having on one side a learning module and on the other side said set of related questions and for each question the corresponding answer or a pointer to said corresponding answer.

31. A method according to claim 29 or 30, wherein the progress chart is created from a MxN matrix of cells by designating some cells as active and other cells as inactive such that said active cells define the path.

32. A method according to claim 29, 30 or 31, wherein the progress chart comprises a depiction of the Periodic Table of Chemical Elements, the learning modules being equal in number to the Chemical Elements, each learning module being identified by the atomic number of the respective one of said chemical elements in said table.

33. A method according to claim 29, 30 or 31, wherein the progress chart comprises a matrix of which each cell depicts a concept behind a section or subsection of the Canada’s Food Guide of Health Canada.

34. A method according to claim 29, 30 or 31, wherein the progress chart comprises several rows each depicting a segment of a double-helix representing the structure of deoxyribonucleic acid (DNA), cells of the matrix depicting nucleotide links of the double-helix each nucleotide link being numbered to correspond with a respective one of the learning modules.

35. A set of game components for use by participants/players playing an educational game to learn, at least partially, a prescribed corpus of information, the set of game components comprising a game board and at least one set of playing cards and a marker, the game board showing a path between a starting point and a finishing point, the path comprising as a series of cells or steps, preferably contiguous, to be traversed by the marker of that participant as the game progresses, each of the playing cards containing a respective one of a set of learning modules together making up the corpus of information.
to be learned by that participant, each playing card further carrying at least one question about the corresponding learning module and either the answer to the at least one question or a link to the answer, the together with a set of rules for the participants to follow when in playing the game.

36. A set of game components for use by one or more participants, said components comprising:

- a game board showing a path between a starting point and a finishing point,
- the path comprising a series of cells or steps, preferably contiguous, to be traversed by a marker of at least one participant as the game progresses,
- at least one set of playing cards equal in number to the series of cells or steps, each playing card bearing
  - an identifier identifying a respective one of the cells or steps
  - a learning module comprising a snippet of information to be learned, and
  - at least one question about said learning module and either the answer to the question or a pointer to the answer,

the set of components further comprising a set of rules for the at least one participant to follow when in playing the game.

37. A set of components according to claim 36, wherein the plurality of learning modules together constitute a predetermined corpus of knowledge to be acquired by game participants during one or more game playing sessions.

38. A set of components according to claim 36 or 37, wherein each of the learning modules is provided on one side of a respective one of a set of playing cards and the related question(s) are provided on the other side.
39. A set of components according to claim 36, 37 or 38, wherein a plurality of learning modules are provided, each for use by a different participant/player, the content of at least one of said sets of learning modules differing from the content of the other set or sets of learning modules.

40. A set of components according to any one of claims 36 to 39, wherein one progress chart is configured for sharing by two or more participants, each participant using markers that can be distinguished from markers of the or each other participant.

41. A game board for use in an educational game to learn about one or more of the Periodic Table of Elements, chemical compounds and basic chemistry, the game board comprising at least one depiction of the Periodic Table of Elements and a set of spots, corresponding in number to the number of rows in said Table.

42. A game board according to claim 41, comprising a plurality of depictions of the Periodic Table of Chemical Elements, each depiction for a respective different one of a plurality of players, there being a said set of spots for each depiction.

43. A game board according to claim 41 or 42, further comprising a single winner's spot common to all participants.

44. In combination, a game board according to claim 42 and a plurality of sets of playing cards, each playing card in each set having a number corresponding to a respective one of said elements in said Periodic Table of Chemical Elements.

45. A method of designing a game board wherein cells of an MxN matrix of cells are designated as active or inactive such that the active cells form a desired progress chart for each participant whereby that participant's prowess in correctly answering selected questions may be tracked.
46. A game board having at least one array of cells formed from an MxN matrix of cells wherein cells are designated as active or inactive such that the active cells form a desired progress chart for tracking prowess of a participant in correctly answering selected questions, the game board comprising a physical medium such as wood, plastic, metal cardboard, or a display of a computer terminal or an electronic medium.

47. A game board having at least one array of cells for tracking prowess of a participant in answering questions selected using at least one set of playing cards wherein each playing card is numbered to correspond to a respective one of said cells.

48. An active learning system or method of learning through play for use by at least one participant and comprising:
   (i) an active learning board on a physical medium, for example wood, plastic, metal cardboard, display of a computer terminal or an electronic medium;
   (i)(a) the board comprising one or more arrays of cells, for example one or more MxN matrices of cells, the cells in the or each matrix arranged in M rows and N columns;
   (i)(b) some of the cells on the board being active or inactive, a selection of cells being set as inactive to obtain a design specific structure/shape to the cell distribution on the board;
   (i)(c) each active cell on the board being assigned a sequential number in the range from one to the maximum number of active cells in the matrix, inclusively;
   (ii) a plurality of cards on a physical medium, for example wood, plastic, metal cardboard, display of a computer terminal or an electronic medium, equal in number to the number of active cells in a said array, each card bearing the same sequential number assigned to a respective one of the cells;
   (iii) the board further comprising one or more additional features selected from a winning zone, a common playing area and a plurality of individual playing areas, the rules specifying use of the additional features during the active learning process/game.
49. An active learning system or method according to claim 48, wherein each card has a learning module on one side and a set of questions on the other side, and, optionally, an information module on said other side.

50. An active learning system or method according to claim 48 or 49, wherein the learning modules are derived from a conventional source of information, for example a text book, the set of active learning modules constituting the corpus of knowledge associated with a conventional source of information such as a school text book.

51. An active learning system or method according to claim 48, 49 or 50, wherein each learning module comprises a textual narrative with or without pictures and graphs of relating to an item of knowledge that is to be learned.

52. An active learning system or method according to claim 49, wherein the information module contains a summary of information relevant to the corresponding learning module presented on the other side of the card.

53. An active learning system or method according to claim 49, wherein there are associated with the set of questions their respective answers or pointers to learning module sections containing the answer.

54. An active learning system or method according to any one of claims 48 to 53, further comprising a plurality of reward tokens on a physical medium, for example wood, plastic, metal cardboard, display of a computer terminal or an electronic medium, for receipt by players during a session/game, each reward token being usable by a recipient player to affect that participant/player's progress.

55. An active learning system or method according to claim 54, wherein at least some of the reward tokens are each associated with a respective one of the cells and awarded to a participant/player who attains that cell.
56. An active learning system or method according to any one of claims 48 to 55, wherein progress is further determined by chance selection means comprising a physical medium, for example wood, plastic, metal cardboard, display of a computer terminal or an electronic medium, for example, one or more dice or other random-number generating means.

57. An active learning system or method according to claim 56, wherein the chance selection means determines not only the selected one of the questions but also the degree of progress to be made by the participant if the participant answers the posed question correctly.

58. An active learning system or method according to any one of claims 48 to 56, wherein the rules prescribe for the participant to have the option of getting help to answer or choosing to answer a different question instead of the question selected from said corresponding set of questions relating to the selected learning module.

59. An active learning system or method according to any one of claims 48 to 58, wherein said progress is tracked by means of a progress chart demarcated according to the corpus of knowledge, a suitable marker being used to identify the participant's current position between said starting and finishing points of the progress chart.

60. An active learning system or method according to any one of claims 48 to 59, wherein said series of cells are sub-divided into groups and the progress chart further comprises, for each group, one of a plurality of spots for receiving markers to indicate traversal of the group of cells.

61. An active learning system or method according to any one of claims 48 to 60, wherein said progress chart comprises at least one depiction of the Periodic Table of Chemical Elements, each cell of the progress chart corresponding to a respective one of the chemical elements, the plurality of learning modules being equal in number to the
chemical elements and identified by the number of a respective one of said chemical elements in said table.

62. An active learning system or method according to claim 49, wherein the playing cards are physical cards each having on its reverse side the respective learning module and the corresponding set of questions on its obverse side, or computer/electronic generated multimedia representations of playing cards having respective learning modules and sets of questions.

63. An active learning system or method according to any one of claims 48 to 62, comprising a plurality of said sets of learning modules, the content of at least one of said sets of learning module differing from the content of the other set or sets of learning modules.

64. An active learning system or method according to any one of claims 48 to 62, comprising one or a plurality of identical sets of learning modules for use by a plurality of participants.

65. A method of creating an active learning system comprising the steps of:

(i) identifying a distinct source of information;

(ii) parsing the information into a plurality of learning modules together making up a corpus of knowledge to be learned, for example by traversing the source information to extract learning modules or by copying page-by-page into respective learning modules;

(iii) for each of the learning modules, devising a set of related questions or facts from which questions can be derived and posed to be answered by a participant during a learning session and a corresponding set of answers to the questions;

(iv) setting out rules prescribing a sequence of events for at least one learning session during which a participant selects learning modules, individually and, in succession and, for each selected learning module, seeks to answer at least one of the corresponding questions.
66. A method of creating an active learning system according to claim 65, wherein the rules prescribe for the participant to select the learning module using random selection means, for example dice.

67. A method of creating an active learning system according to claim 66, further comprising the step of providing a progress chart, for example a game board, demarcated with a path to be progressed by a participant between starting and finishing points of the learning session.

68. A method of creating an active learning system according to claim 67, wherein the progress chart comprises a depiction of the Periodic Table of Chemical Elements, each of the associated learning modules being identified by the number of a respective one of said chemical elements in said table.

69. A method of creating an active learning system according to claim 68, wherein a plurality of said progress charts are provided, each for a different one of a plurality of participants.

70. A method of creating an active learning system according to claim 65, wherein the learning modules are provided on a corresponding plurality of cards, respectively, on physical or electronic media, each card having an identifier linking same to a particular learning module, at least one question about the learning module, and either the required answer to the question or a pointer/link to the answer to the question.

71. A set of game components for use by participants/players playing an educational game, the set of game components comprising a game board, at least one set of playing cards and a marker for each participant/player, the game board showing a path between a starting point and a finishing point, the path comprising a series of cells or steps, preferably contiguous, to be traversed by the marker of a participant as the game progresses, each of the playing cards containing a respective one of a set of learning
modules together making up a corpus of knowledge/information to be learned by that participant, each playing card further carrying at least one question about the corresponding learning module and either the answer to the at least one question or a pointer/link to the answer, the set of game components further comprising a set of rules for the participants to follow when playing the game.

72. A set of game components according to claim 71, wherein each of the learning modules is provided on one side of a respective one of a set of playing cards and the related question(s) and answer(s) are provided on the other side.

73. A set of game components according to claim 71, wherein a plurality of learning modules are provided, each for use by a different participant/player, at least one of said sets of learning modules being different from the other sets of learning modules either by level of knowledge or ability of the participant/player or comprising a different subject.

CLAIMS - CARD GAME

74. An active learning educational card game comprising a set of cards and rules for playing at least one card game using said set of cards, each of said cards representing a respective one of the chemical elements listed in the Periodic Table of Chemical Elements and carrying information about said one of the chemical elements, the set of cards comprising a card for every one of the known chemical elements listed in the Periodic Table, the rules prescribing for cards to be distributed to the players who, in their turns in a particular round of the game, attempt to earn/acquire cards and/or to use cards in play to form chemical compounds, points being scored according the nature of the cards earned/used.

75. A card game according to claim 74, wherein the rules define one or more subsets of the cards and prescribe for substitution of cards belonging to the same subset when forming said chemical compounds.
76. A card game according to claim 75, wherein said one or more subsets comprise a column-substitutable subset of cards listed in the same column of the Periodic Table of Chemical Elements, and the rules prescribe for substitution of cards belonging to said column-substitutable subset when forming said chemical compounds.

77. A card game according to claim 76, wherein each card in said column-substitutable subset carries a number in the range from 1 to 17, inclusive, indicating that the card can be used to replace any element in a compound, provided the element belongs to the column identified by said number.

78. A card game according to claim 75, 76 or 77, wherein one of said one or more subsets comprises an element-substitutable subset of cards which can be substituted on an individual basis and the rules prescribe for substitution of the cards of said element-substitutable subset element-for-element when forming said chemical compounds.

79. A card game according to any one of claims 75 to 78, wherein one of said subsets comprises cards each carrying an indicator indicating that the card can be used to represent a plurality of any given element when forming said chemical compounds.

80. A card game according to any one of claims 75 to 78, wherein one of said subsets comprises cards each carrying an indicator indicating that the card can be used to represent a plurality of any given group of elements when forming said chemical compounds.

81. A card game according to any one claims 74 to 80, wherein at least one of the cards carries an indicium and the rules prescribe for the playing of the indicium-carrying card to influence the progress of the game in a prescribed way.

82. A card game according to claim 81, wherein the rules prescribe for the indicium-bearing cards to negate or trump other cards played during that round, whether
before or after the indicium-carrying card.

83. A card game according to claim 81 or 82, wherein the set of cards includes one or more additional indicium-carrying cards and the rules prescribe for one or more players to play one of the additional cards in the same round of the game, the indicium-carrying card whose chemical element has the higher or highest atomic number negating the or each indicium-carrying card already played in that round.

84. A card game according to claim 81, 82 or 83, wherein the indicium indicates that the element is radioactive.

85. A card game according to claim 84, wherein the indicium comprises an icon as used to warn of radioactive material.

15 Dynamic Sponsorship

86. An active learning system according to any one of claims 1 to 13, 28, 48-64 or an active learning educational card game according to any one of claims 74 to 80, for playing in a networked or computer-based environment comprising a network element serving as a sponsorship manager and a network element or client computer serving as a sponsor client, the sponsorship manager communicating with the sponsor client and with the active learning system or card game, the active learning system of card game being provisioned for communication with the sponsorship manager to associate sponsored rewards with selected cells or questions to be answered, the arrangement being such that the sponsor may sponsor said rewards dynamically while the active learning session or game is in progress.
**Newton's laws of motion**

1. Who was the scientist who gave us the Laws of Motion?
   - See Ans 1
2. How many Laws of Motion are there?
   - Read the learning module.
3. What is another name for the first law of motion? (see Ans 3)
4. Which law explains why we need to wear seatbelts?
   - First Law of Motion
5. Which law says that force is equal to mass times acceleration (F=ma)?
   - See Ans 5

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Relations between the forces acting on a body and the motion of the body, formulated by Isaac Newton (Ans 1). The laws describe only the motion of a body as a whole and are valid only for motions relative to a reference frame. Usually, the reference frame is the Earth. The first law, also called the law of inertia (Ans 3), states that if a body is at rest or moving at constant speed in a straight line, it will continue to do so unless it is acted upon by a force (Ans 4). The second law states that the force (Ans 5) F acting on a body is equal to the mass m of the body times its acceleration a, or F = ma. The third law, also called the action-reaction law, states that the actions of two bodies on each other are always equal in magnitude and opposite in direction.
Uranium
Neutrons 141-146. Most common isotopes U-238, U-235. It has higher atomic weight and is denser than lead.
1. U-238 can be transmuted to Plutonium in nuclear reactor - T/F?
2. ___ is the only naturally occurring fissile isotope of Uranium.
3. Why is Uranium used in dating the age of the Earth?
4. Name the particle emitted during the decay of Uranium.
5 In nature, 99.284% of Uranium atoms exist as ___
FOR ANSWERS: SEE [#] IN THE LEARNING MODULE

In nature, Uranium atoms exist as Uranium-238 (99.284%) [5], Uranium 235 (0.711%), and a very small amount of Uranium-234 (0.0058%). Uranium decays slowly by emitting an alpha particle [4]. The half-life of uranium-238 is about 4.47 billion years and that of uranium-235 is 704 million years, making them useful in dating the age of the Earth [3]. Uranium-235 has the distinction of being the only naturally occurring fissile isotope [2]. Uranium-238 is both fissionable by fast neutrons, and fertile (capable of being transmuted to fissile Plutonium in a nuclear reactor [1]).

92

U-238 (99.284%), half life: 4.47 billion years. U-235 (0.711%), half life: 704 million years
1. Uranium belongs to lanthanide series in the periodic table - T/F?
2. How many neutrons can there be in a Uranium nucleus?
3. Is Uranium denser than gold? (Y/N)
4. ____ has the highest atomic weight among all naturally occurring elements.
5 What is the atomic weight of Uranium with half life 4.47b. years?
FOR ANSWERS REFER TO THE LEARNING MODULE

Uranium (U, 92) is a silvery-white metallic chemical element in the actinide series of the periodic table. Besides its 92 protons, a Uranium nucleus can have between 141-146 neutrons, with 146 (U-238) and 143 (U-235) in its most common isotopes. Uranium has the highest atomic weight of the naturally occurring elements. Uranium is about 70% denser than lead, but not as dense as gold or tungsten. It is weakly radioactive. It occurs naturally in low concentrations (a few parts per million) in soil, rock and water, and is commercially extracted from uranium bearing minerals.
**Fig. 6A**

**Li Lithium**

1. When Chlorine gains an electron and it is known as a(n) _____.
2. How many groups are there in the periodic table?
3. How many rows are there in the periodic table?
4. The periodic table organizes elements by _____.
5. In general, metals are brittle - T/F.

**Answers:** ANION, 18, 7, ATOMIC NUMBER, FALSE.

**Fig. 6B**

**Eu Europium**

1. One of the rare-earth metals with atomic numbers between 57 and 70.
2. Positively or negatively charged atom or group of atoms.
3. Positively charged ion.
4. Horizontal rows of the periodic table.
5. Negatively charged ion.

**LANTHANIDE, ION, CATION, ANION, PERIOD**

**Fig. 6D**

**U Uranium**

1. Gamma rays may be emitted during radioactive decay - T/F.
2. Geiger counters primarily detect alpha radiation - T/F.
3. All radioactive isotopes have the same half-life - T/F.
4. All nuclear reactions are transmutation reactions - T/F.
5. Stable nuclides decay slowly and have long half-lives - T/F.

**Answers:** PLEASE REFER TO THE LEARNING MODULE.

**Fig. 6D**

**Ar Argon**

1. The majority of elements are _____.
2. The lanthanide and actinide series make up the inner transition metals - T/F.
3. In general, metals are ductile and malleable - T/F.
4. Alkaline earth metals are more reactive than alkali metals - T/F.
5. Elements in the halogen family are most reactive - T/F.

**Answers:** PLEASE REFER TO THE LEARNING MODULE.
Li
Lithium
2,1
1. Lithium has highest specific heat among all solid elements - T/F.
2. How many groups are there in the periodic table?
3. Lithium is corrosive and requires care to avoid skin contact - T/F.
4. The periodic table organizes elements by _______.
5. In general, metals are brittle - T/F.
ANSWERS: T, 18, T, ATOMIC NUMBER, F

Fig. 13A

Eu
Europium (E)
2,8,18,25,8,2
1. One of the rare-earth metals with atomic numbers between 57 and 70
2. Positively or negatively charged atom or group of atoms.
3. Positively charged ion
4. Horizontal rows of the periodic table
5. Negatively charged ion
LANTHANIDE, ION, CATION, PERIOD, ANION

Fig. 13B

U
Uranium
2,8,18,32,19,2
1. Gamma rays may be emitted during radioactive decay - T/F.
2. Geiger counters primarily detect alpha radiation - T/F.
3. All radioactive isotopes have the same half-life - T/F.
4. All nuclear reactions are transmutation reactions - T/F.
5. Stable nuclides decay slowly and have long half-lives - T/F.
ANSWERS: PLEASE REFER TO THE LEARNING MODULE

Fig. 13C

Ar
Argon
2,8
1. The majority of elements are _______.
2. The lanthanide and actinide series make up the inner transition metals - T/F.
3. In general, metals are ductile and malleable - T/F.
4. Alkaline earth metals are more reactive than alkali metals - T/F.
5. Elements in the halogen family are most reactive - T/F.
ANSWER: PLEASE REFER TO THE LEARNING MODULE

Fig. 13D
Uranium (U, 92) is a silvery-white metallic chemical element in the actinide [1] series of the periodic table. Besides its 92 protons, a uranium nucleus can have between 141 and 146 neutrons [2], with 146 (U-238) and 143 (U-235) in its most common isotopes. Uranium has the highest atomic weight of the naturally occurring elements[4]. Uranium is about 70% denser than lead, but not as dense as gold[3] or tungsten. It is weakly radioactive. It occurs naturally in low concentrations (a few parts per million) in soil, rock and water, and is commercially extracted from uranium-bearing minerals.

Fig. 14A

Fig. 14B

1. Uranium belongs to lanthanide series on the periodic table (t/f)
2. How many neutrons can be there in Uranium nucleus?
3. Is Uranium is denser than gold?
4. Does it has the highest atomic weight among all naturally occurring elements (t/f)
5. What is the atomic number of Uranium?

For Answers: See the Learning Module