Can Rote Memorization Be Fun?
A Game Shell for Concept Matching with Java and XML

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Abstract
The concepts of some of the most popular games can be extended to become suitable as a presentation shell that can accommodate a wide variety of educational contents. As an example the popular “Concentration” board game was implemented as a Java applet that permits the teacher to define the underlying tasks independently in XML form based on an expressive grammar. The tasks can be accumulated within a database and lessons can be defined through filtering the database with based on keywords, difficulty levels and other task attributes. Preliminary experience indicates that such a game can not only replace regular exams, but also be employed as a learning tool without sacrificing its appeal as a game. To help clarify the students’ user models the game will be augmented by an “observer” module that records all the student interactions and an “analyzer” module that displays graphs summarizing the interactions.

1. Introduction

The appeal computer and video games exert on children and adults alike is one of the byproducts of the information age. The computer game industry is one of the most prolific and fastest growing branches of the computer industry. On the other hand, educators and parents fear the negative consequences of this trend – playing games seems to detract children from their learning. Their worries are understandable, as the vast majority of computer games are virtually void of any learning content. Is there a way to reuse popular computer games and “fill” them with educational contents without sacrificing their quality as entertainment?

The developers of educational software typically develop a new game concept in the hope that the students will find it entertaining (e.g. [1]). Even if the game is used within several lessons a game-specific authoring system is usually needed to adapt the game to different task sets.

This article shows how the concept of a popular board game can be extended and generalized to accommodate arbitrary matching tasks. It further demonstrates how to construct the game as a separate presentation shell independent on the definition of the tasks it manages and discusses the very limited, but nevertheless encouraging experience with such a shell.

There are ample references in the literature that suggest the usefulness of games in teaching (e.g. [2]) and reports that simulation games are indeed effective educational tools (e.g. [3]). Only few articles, however investigate the educational effects of computer games. Positive learning outcomes, such as enhancement of inductive reasoning, problem solving abilities and metacognitive analysis are reported in [4]. The effectiveness of presentation shells based on popular board and computer games remains to be investigated. To enable the analysis of player’s interactions the game shell will be augmented with an observer – analyzer system based on the approach described in [5].

2. Exam is a game is an exam…

Let us look at the basic concepts that most games have in common. During a typical game session, the players are confronted with a series of tasks they are supposed to accomplish. Usually there is a score that changes depending on how well the players complete the tasks. There may be even a table of “high scores” which lists the best scores ever achieved. A good game is stressful: the player, for instance, may “die” if the tasks are not achieved within a time limit. Interestingly, some very popular games go not have a “happy end” and the game always ends with the player’s “death”.

Now let us substitute the word “game” in the preceding paragraph by “exam.” An exam consists of tasks and the students try to achieve a good score. The
names of the students with the best scores may be read aloud. The test is stressful and usually a time limit is imposed on its completion. Conceptually, a game and a school exam have a common basis. The stress and lack of positive reinforcement that educators regard as an impediment to learning seems to be a motivating challenge in a game.

There is, however, one major difference between a game and an exam that can be easily remedied – a game presents the tasks in much more motivating way than a typical exam.

The software developers who construct educational game have two options: They can either invent a new exciting game concept or adapt an existing successful design. Since only very few of the new games become commercially successful, it is advisable to reuse a game that has a proven track record.

3. Concentration game and its variations

The “Concentration” or “Memory” game is a popular board game for two or more players. The game consists of square picture tiles which are initially placed on a table face down forming a large rectangle. The tiles come in pairs – there are always two tiles that display the same picture. The players take turn in turning over two of the tiles to show their pictures. If the uncovered pictures are the same, then the player collects both tiles and continues turning over another two tiles. When the two tiles show different pictures, the tiles are turned face down again and the next player can try his or her luck. The game ends when all tiles are collected – the player who collected most tiles is the winner. In the beginning, most of the tiles turned over show different pictures. In later stages of the game it is likely that the first tile turned over displays a picture that was uncovered before. If the player remembers where exactly where the matching tile is, he or she can turn it over and collect the pair.

As the players’ success depends on how well they recognize the pictures, those who have played the game before and are familiar with the pictures have some advantage. But it is more important to remember the exact place where a picture appeared. Therefore, the concentration board game is not completely without educational merit – it relies on visual memory and trains in particular spatial memory.

Can this game become more “educational,” i.e. train more that visual and spatial memory? The first variation could involve the hidden underneath the tiles. Instead of pictures the tiles could reveal text: words, sentences or letters. Such a game could be useful in learning a foreign alphabet, e.g. Hiragana, Kanji or Cyrillic. Or the tiles could reproduce a sound when squeezed to teaching pronunciation of foreign vocabulary or to making pre-school children familiar with the sounds of domestic and wild animals.

The next variation becomes obvious when we realize that the concentration game is based on matching two representations of a concept. In the original game, the two representations are two identical pictures. But the pictures don’t need to be identical to preserve the game’s appeal – imagine, for instance, a concentration game where the pairs of tiles to be matched show related pictures: a hammer and a nail, a teacher and a student, the outline of a country’s border on a map and its a flag. Again the media can be varied: a country’s flag and first chords of its anthem, or the name of a city and the photo of its famous landmark. On a computer, the media can be even more varied. For instance, a video of a chemical experiment can be matched with the formula of the corresponding chemical reaction.

The next generalization of the concentration game is to provide for more than two representations of a concept. As a consequence, the player has uncover three (or more) tiles representing the same concept to collect them, e.g. a country’s name, its flag, and a famous landmark in its capital. In the elementary math context, tiles with simple expressions may be collected if they result in the same number, e.g. “12-3”, “3*3”, and “18/2”. In the CALL (Computer Aided Language Learning) context, tiles may represent a word in the native speaker’s language, its English equivalent(s), an explanation of the word and a sample sentence where it is used in context.

The concentration game becomes more cumbersome and more difficult when more than three tiles are to be matched. To simplify the game again we can allow a tile to combine several representations of a concept. Preferably, a tile will combine related representations and will not “give away” what the matching tile need to contain. While one tile may represent a word in the native speaker’s language and a particular context in which it is used, the matching tile can show its English translation and a sample sentence where the English word is used.

In addition, numerous variations are feasible if the concentration game is converted into a computer game. Other media formats become available: besides animation and video, computerized tiles can contain entire multimedia presentations (e.g. in SMIL format) or even WWW (World-Wide Web) pages. On a computer, each tile can become interactive and allow the player to replay a sound, pause a video, or explore the links to other WWW pages with a more detailed explanations of the concept.
Because the computer can easily maintain and display score, the concentration game becomes interesting as a single player game. Instead of taking turns and counting the number of collected tiles, the player receives an initial number of points. While each trial costs a certain number of points, collecting matching tiles wins many more. The goal becomes to achieve the best score at the end when all tiles are collected. The costs and rewards can be more subtle – missing a tile that was already uncovered can cost more or, collecting tiles that could have been collected before can earn less points.

The flexibility of a computer becomes indispensable when the concentration game is to be used as learning tool rather than as a test of knowledge acquired elsewhere. Suppose that students want to learn vocabulary that they have never seen before. It would be indeed a tedious trial and error exercise – exponentially more tedious with increasing size of the board – to find matching tiles by chance. Even if the students learned something, it certainly would not be very efficient. With a computer, the player can “buy a hint” which displays all the tiles face up and lets the player explore the board, i.e. select a tile and see all the tiles that must be matched. To simplify the learning, the “hint” may present the tiles that belong to the same concept grouped together irrespective of their original position on the game board. This also maintains the fun of having to memorize the position of the tiles.

Other variations of the computerized concentration game can be devised to make it more difficult or to employ it for another category of tasks. To increase the difficulty of spatial memorization, the tiles can slowly rotate or rotate in steps, e.g. 90 degrees after each move. If the order in which the tiles are uncovered plays a role, then the game can be used for composition tasks. For instance, the steps in a procedure may have to be uncovered in the correct sequence, e.g. to test the understanding of a computer algorithm. To give another example, the player may have to reveal words in the correct order to form a valid sentence in a CALL context.

The most important aspect of the preceding discussion is that the concentration game can be used to let a player solve arbitrary matching tasks, i.e. tasks that require the player to find and select several related representations of a concept.

4. Concentration game shell

A reusable computerized concentration game must be constructed in such a way that allows teachers to fill the game with arbitrary new tasks. There must be a simple way to define the tasks and then associate the definition with the game. The teachers can then construct tasks and then determine which subset of the tasks will be featured in the game. A lesson can be accompanied by one or more game sets. The tasks themselves as well as the game sets can be maintained in a database.

When the implementation of the concentration game accommodates tiles that contain arbitrary representations of a concept, it becomes a shell whose only purpose is to accept the specification of tasks, present them to the players and interact with the players according to the logic of the game. In the MVC (Model-View-Controller) parlance used often in Software Engineering, the model – or data – portion of the game software is separated from its View-Controller – or presentation and logic/interaction – part. Figure 1 illustrates how the separation of the software layers enables the easy exchange of contents.

In order to achieve the separation of the game shell from its contents, the definition of the content in terms of a set of tasks must be constructed in a form that the shell understands, i.e. according to specific rules. One possible way is to define a database with entry forms where a teacher fills in the definition of the tasks. The second option is to provide a separate application devoted to the specification of the tasks.

Another possibility follows the WWW model: the data is defined in textual form that includes special mark-up tags intermingled with actual text data. The rules that a correctly marked-up document must follow can be described in a grammar. The Extended Markup Language (XML) became a widely accepted means of formulating such a grammar. XML allows the software designers to define their own HTML-like tags with attributes and rules for ordering and nesting of the tags within a document. As XML is supported by all of the major players in the...
software industry, several parsers for XML are available thus simplifying the incorporation of XML-based data within a software application. Portability is another important reason to use XML: a document defined using one grammar can be easily translated into a form that obeys another grammar provided that the grammars are sufficiently similar. As a consequence, it was only natural to base the initial implementation of the concentration game shell on XML.

As more and more schools develop their own WWW sites and teach the students how the construct their own home pages, it can be expected that the number of teachers who are accustomed to using HTML will grow. Nevertheless, very few will ever look at the HTML grammar, or even know that such grammar exists. An XML grammar must follow the often complicated and arcane syntax prescribed by the XML rules. Only the very inquisitive among the teachers will be able to study an XML grammar and construct correct documents. Therefore, an XML grammar for a definition of tasks must be as simple and intuitive as possible so that it can be easily deduced from a few sample documents.

The emerging XML editors may become alleviate the problem of easy authoring of documents that conform to the grammar that governs the definition of game tasks. However, even the best XML editors and the simplest grammar will not make the specification procedure as simple as a custom task entry application that eliminates syntax errors. Even after a custom entry program becomes available, however, XML documents can serve as a convenient and portable intermediate form of game descriptions.

There is another advantage of using XML to define data. A task is defined as a set of concept representations. In a large tasks database it will be advantageous to store all of the representations together, e.g. an English word, its translation to other languages, its pronunciation, its definition, its usage, and an icon representing it. For a particular game, the teacher may want to use only a subset of the available representations, e.g. the English word and its definition. In addition, several descriptive attributes may be attached to a task, such as a set of keywords, a number indicating its difficulty level, and the name of lesson where it is taught. These attributes can make it simple for teachers to define a game as a subset of existing tasks – they can include or exclude all tasks described by a set of keywords, and/or range of difficulties or lessons. An XML document can also define such game filters.

The “look and feel” of the concentration game shell itself can be parameterized within an XML document. The look is described by such layout parameters as the number of rows and columns, the image displayed on the back of a tile, the type of content the tiles contains. The “feel” parameters determine the behavior of the game shell, e.g. how much points the player receives initially, how much a move and a “hint” costs, and what is the reward for a collected tile.

Using XML for all aspects of task definition and filtering, as well as game shell parameterization achieves several goals:

1) Even though the XML format will be challenging for most of the teachers, using the same methodology will simplify the game specification for those who are willing to learn it.
2) The implementation of the game shell is greatly simplified.
3) Because of reduced software maintenance costs, the grammar can be easily fine-tuned.

5. The history of a grammar

The design of a good XML grammar is a balancing act. While short tag names are easy to write and make the document concise, expressive tags names improve the document’s readability. Often the XML document can be structured either using tag attributes or nested tags – this is another decision that affects the readability.

The original version of game grammar defined the game as a set of <concept> tags where each concept was specified as a collection of tags corresponding to the media used to display the concept representation, such as <text>, <picture>, and <sound>. This version was CALL oriented as it introduced tag attributes foreign and original to distinguish among the different types of text when filtering was applied. While such a grammar was easier to apply for a CALL teacher, it introduced concepts that are not applicable in other subjects. More importantly, the <concept> tags implied that the data can be only used for concept matching.

In subsequent revisions the grammar become more general at the cost of becoming less expressive for specific applications. The current version of the grammar divides the game specification into four parts: The <actions> and <looks> tags are specific to the concentration game shell – they define the “feel” and “look” parameters of the shell. These tags are followed by a <filter> section that narrows down the set of tasks. The remaining part of the document consists of <task> tags. To accommodate future games that can present other types of tasks than concept matching – for instance multiple choice –, each task is defined as a <problem> tag followed by a set of <solution> tags and <distractor> tags. Each of the latter three tags can contain <text>, <uri>, or
The type attribute of the <text> tag classifies the text – its values can be used to filter out unwanted types of representations. The media attribute of the <uri> tag determines whether the “uniform resource identifier” will be interpreted as sound, image or a WWW page. Defining the text type and uri media as attributes instead of tags makes the grammar easily extendible in the future. Finally, the <id> tag is reserved to maintain references to tasks within a database.

The following excerpt from a game specification document shows how a task can be defined:

```xml
<task level="3">
  <problem>
    <text type="word">frightened</text>
  </problem>
  <solution>
    <text type="definition">to be afraid or scared</text>
  </solution>
  <solution>
    <text type="example">when you have seen a horror movie</text>
  </solution>
</task>
```

6. Experience with the concentration game

The concentration game shell has been conceived and constructed while the author was on a leave in Thailand. He was participating as a guest in the activities of a bilingual school in the vicinity of Bangkok. The bilingual schools are a fairly recent addition to the educational landscape in Thailand, designed to fill the gap between the inexpensive state schools and the expensive and exclusive international schools. Because the teachers and the majority of students in the international schools are foreigners, most of their students speak very good English. While the teachers in the bilingual schools are native English speakers, the students are, with a few exceptions, only Thai and their proficiency in English varies.

Although the experience with the concentration game has been very limited, the results are encouraging. The author participated in a half-day tutoring session with the goal to prepare grade five students for the upcoming tests in several subjects. The concentration game shell was filled with some of the material the students studied for the test – English vocabulary with the definitions of each word, also in English. Three students stayed after the tutoring session and played the game. None of the students needed long introduction – the author showed them only how to collect the first pair of tiles and then they played a new game on their own. Because only two computers were available, one student played the game on her own in a separate classroom. She came back after 20 minutes when she succeeded to collect all the tiles. The two other students played together, one wielding the mouse and the other arguing with her companion where to click. None of the three students seemed to perceive the game as a boring repetition of the vocabulary from the past lessons.

Even though the experience with the game is not statistically significant, it indicates that if educational contents is presented in an attractive game format, at least some students will perceive it as a game and not as a test or an educational lesson.

7. Implementation

The concentration game shell has been constructed in Java 1.2 using the Swing libraries and Sun’s implementation of the XML parser (ProjectX). The game has been implemented in such a way that it can be used as a standalone application or incorporated in a WWW page as an applet.

The XML grammar that governs the game definition documents is contained in a separate file. The game definition document is also a separate file. Since the names of the grammar and the game definition files are supplied either as command arguments of the standalone version of the game or as applet parameters in the WWW version, switching among existing content specifications for the game shell is a trivial task.

Because a tile is a separate container of display components, it can contain several representations of a concept as postulated by the game grammar. Currently implemented are the following types of media representations: text in arbitrary color, font family, font style and font size, image, and sound. Because sounds are represented by buttons, they play not only when a tile is turned, but also when the player clicks the corresponding button.

The shell software also supports the filtering of concepts according to the grammar.

Besides the English vocabulary game described above, a task sets for the Thai alphabet is currently being developed. The Thai alphabet game will use the following representations: 1) a Thai letter, 2) the corresponding Thai word, 3) a picture of this word, 4) the pronunciation of the
word, and 5) the English equivalent of the word. The words associated with each of the letters are standard and Thai kindergarten and primary schools employ colorful tables that depict a letter with the corresponding word and a simple picture. Such a game will be useful not only for the Thai students in kindergarten and primary schools but also for foreigners who attempt to master the intricacies of the Thai language – the words are also used for spelling, e.g. when spelling names on a phone. Figure 2 shows a screen shot of the Thai alphabet concentration game.

8. Future plans

To help clarify the students’ user models in controlled experiments, the author is developing an “observer” module that records all the student interactions with the game on a log file. As the Java dialog components deliver a daunting plethora of interaction events that are confusing even for an experienced programmer, the observer lets the experimenter define a filter so that types of events are ignored during the recording.

Even though the observer files can be viewed as text, the size of the files makes it hard to read them in their original form. Therefore, companion modules are needed to offer the experimenter a more comprehensive means of analysis. The “player” module simply replays the entire game session. (The exact replay of mouse events including cursor movements has just become available in the 1.3 version of the Java Development kit.) The “analyzer” module offers a of graphical representation of the interactions as a two dimensional chart where the events are shown in relation to the time when they occurred.

The game shell itself will be complemented to accommodate concept representations in other media formats than text, image, and sound. Most of the desired media, such as video or a web page necessitate a display
in a separate window. This can be best achieved within the implementation of the game shell as a Java applet – the applet can open another window of the browser and display there a web page or start there a plug-in.

Since the data definition has been separated from its presentation as a game, new presentation shells can be constructed. While the new shells will typically present the tasks as a game it is feasible and it may be even desirable to have a shell that displays the tasks in the form of a standard school test.

Several of the software modules that have been already implemented can be reused in the new shells. For instance, the module that converts the parsed document into task data as well as the display of concept representations are common to all shells. Other modules, such as the score display and the management and display of the high scores can be reused in new games.

The definition of all game’s aspects in the form of XML document(s) is too cumbersome for the average teacher. Therefore a custom software application that allows a teacher to specify a game will become a necessity if the game shells are to become a widely used tool in the schools. Once such an application is constructed, it can be deployed on the WWW and the definitions supplied by the teachers can be stored in a database and reused by other teachers, schools and students.

Last but not least, the premise games will remain popular even though they are converted into shells and filled with educational materials has not been tested in controlled experiments. It is likely that some players will reject such games as a ruse to make them study while others will find the games more interesting because another contents presents them with a new challenge. In addition, even the most interesting games become boring when played too often. Do games with educational content become less or more boring with time than their counterparts? Individual differences and personality traits may play a significant role and may be subject of further research studies.

9. Conclusion

The example of “Concentration” board game demonstrates that popular games can be computerized and extended to become mere presentation shells that can be filled with different educational contents. Preliminary evidence suggests that children regard such games shells indeed as games rather than as exams or boring educational tools. This approach suggests that developers of educational software can simply reuse the concepts proven successful in conventional games rather than trying to invent completely new learning tools.

The XML standard allows the software designer to define an expressive form for the construction of tasks presented in a game shell. Even though more convenient means of defining the game contents can be devised the marked up text is readable and can serve as an intermediate database of tasks. Lessons can be defined through filtering the database based on such attributes as keywords and difficulty levels.

Further studies that explore the usefulness of the suggested approach will be simplified by augmenting the game by tools that record all the player’s interactions with the game shell and help the experimenter to analyze these recordings based on the replay of the experimental session and event-time graphs.

10. References


