Concept Gaming

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Abstract

Concept learning belongs to the fundamental challenges of educational technology. Contrary to the current trend of designing and implementing contents for various web–based virtual courses, concept learning requires cognitive tools rather than digital materials. We introduce a novel scheme to generate computer games from concept maps made by a teacher or a learner herself. Concept gaming exceeds the potential of previous software packages for concept mapping in a significant feature: it adds excitement and tension to the process of building a meaningful composition of concepts related to each other. In addition, concept gaming supports learning at various levels, from memorizing up to open problem solving.

1 Introduction

Concept maps are widely discussed means of visualizing one's inner cognitive structures. It is argued that with the help of preparing those structures, one has got a possibility to reflect own conceptions and correct potential misconceptions, thus building a new corrected structure into one's mind. This all has its roots in David Ausubel's learning theory of meaningful learning [2], which Joseph D. Novak later turned into a method now known as concept maps [7]. Concept mapping is widely used to assist learning [6], planning, and problem solving.

With the emergent discussion about concept maps in general, it is natural to extend them by the power of technology. With the new software implementations users have been able to construct a static map of their concepts to help them to clarify their thinking and learning. As an example of such formalisms, the genetic graphs [5] are intended to present processes with static images. This static approach is however quite limited for general use. Gaines [4] and Rautama et al. [8] present a method for dynamic presentation of concept maps as scripts, showing the construction process. There are also techniques, with which the concept maps can be shown through the web interface [4, 9].

These conceptualizing tools have been of great value to teachers and advanced, self–guided learners. In this paper, we propose the idea of concept gaming, which combines the powerful learning tool, concept maps, with a motivating factor—excitement.

In our opinion, the designers of learning environments have got many things to learn from the computer games. Computer gaming is inherently exciting, which creates intrinsic motivation for the youth and also the adults to acquire skills—i.e. to learn—in order to be successful in the game [1]. We argue, that this should be also the case with learning.

Therefore, adding the elements of excitement and success from computer games into a learning tool should serve as means to make using those tools attractive and worth bothering. In concept gaming, the contextually bound concept map building is connected with typical gaming ideas—competition, fight against time, growing challenges, winning oneself, scoring and development of one's skills as a player and simultaneously as a learner.

2 Concept Gaming

A concept map is a graphical representation of interrelated concepts. Concepts are shown as labeled nodes and their relationships as arcs, which may be labeled or unlabeled, directed or undirected. The basis of concept gaming is a selection of game schemes. A game consists of a game scheme run with a certain concept map. Here the concept map and its subject area can be arbitrary, and the map can be made by a teacher or a learner herself or it can be copied from a textbook.

To clarify and concretize our ideas, we introduce some features of a prototype CMG we implemented to test our approach. CMG (short for Concept Map Games) contains currently five game schemes:

1. **Removed concept names:** At first the map is shown without the names of concepts. The correct names are given in a list. The player moves one name at a time from the list to its proper place.

2. **Removed relation names:** This is analogous to the first one, but now the map is shown without the names of relations.

3. **Shuffled concepts:** The names of the concepts have been shuffled. The player tries to correct the map by repeatedly exchanging the names of two concepts.

4. **Shuffled relations:** The start and end concepts of each relation have been randomly reselected. The player should move the relations back to their correct positions.

5. **Trivia:** The player is given a concept and a relation starting from that concept. The player should infer which concept the relation leads to.

These five schemes are only examples of the game types that can be included in CMG. It is possible e.g. to design games that are focused on some certain subject area. In that case the concept maps may have to be constructed according to some guidelines but the game scheme itself can be more detailed and complex.

The concept map is loaded in the beginning of each game. In the end CMG shows the score and the correct answer. Scoring is based on correctness and speed. For example in game scheme 1 each correct concept name gives a certain amount of points. CMG also contains an editor with which the user can create new concept maps. The editor includes tools for constructing a concept map as well as adjusting the visual parameters such as color and appearance of the map elements. After a map is saved, it can be applied to any game scheme.

3 From Closed to Open Gaming

Generative nature is a major difference between a conventional learning game and the idea of concept gaming. A conventional game is typically connected with a single subject area whereas a concept game is a scheme, which generates games on various subjects. A concept map given as input to the generator determines the subject area of the game. Note that this concept map can be a ready–made map or a map made by the user—student or teacher—herself. Generative nature is also present in another respect. The user is able to generate several different games from the same concept map.

The game schemes presented so far require that each game has a fixed target map. In a more general approach, the target map is not necessarily completely specified. The reason for supporting relaxed ways of gaming is to support various learning methods. These methods start from primitive mechanized memorizing ending up to open problem solving (Fig. 1).

The simplest game type is called closed gaming, where the result map of the game is known before the game ends. Closed gaming is considered to help learning methods like repetition and memorizing. Examples of games that belong to these themes vary from basic connectivity problems between concepts to jigsaw puzzle, where concepts should be placed to their correct places.

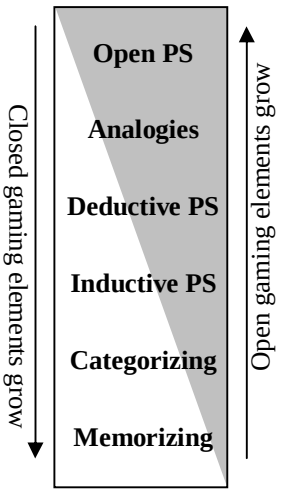

Figure 1. Concept gaming supports variety of learning methods

The most versatile type is open gaming, because of its main idea of being constructive and open–ended. This kind of gaming serves especially the needs of higher learning methods, namely open problem solving skills. The gaming here is not necessarily gaming in the traditional sense, but its idea is to allow a learner to construct new ideas on the basis of one's old concepts. This can be helped by offering the learner new randomized edges or concept nodes to be added into existing concept map. These randomized events are called distant thought models and are considered to help a learner to find novel sights into her work, much like they are utilized in a creativity enhancing software found on the market.

One must note, however, that there is a continuum from closed type of concept gaming to open gaming. Rather than tightly categorizing games, it is more useful to identify the aspects of a certain game that could be expanded or extended towards the targeted educational need. In addition, one game session might consist of several features, some more closed than others. This means that a game can support different learning methods at the same time. For example, a game for ecology education might consist of two–faced nodes, one side

representing a natural phenomenon and the other a concrete example of it. The player is supposed to organize the nodes into a map that represents the interplay between different phenomena. Learning the two faces of the nodes helps one to memorize ecological factors, whereas constructing the interplay supports higher–level learning goals. This essentially takes a concept gamer from a fuzzy, blurred image of conceptual reality towards a more formal and stringent conceptual construct.

4 SWOT Analysis

We have also done a preliminary SWOT analysis from the learner's (Table 1) and teacher's (Table 2) points of view to find out the strengths, weaknesses, opportunities, and threats of our ideas. From the learner's point of view the important strengths of concept gaming are based on its support for variety of learning methods and help for cognitive processes. Cognitive processes are helped in two ways; first concept gaming helps a learner to construct her inner cognitive structures; secondly it helps the learner to make her implicit structures explicit, thus helping in self–re–evaluation of those.

As being a computerized tool, one of the weaknesses of the system is the computer usage skills that are needed for utilization of it. Another weakness is that the learner needs thinking skills that help her to conceptualize and abstract things and phenomena, which on the other hand are developed by using the system. This development as a learner is also one the opportunities that we see this system offers to the learner.

Concept gaming helps a learner to acquire new learning strategies, which helps her to achieve her goals as a learner more efficiently. We also argue that concept gaming brings the tension and excitement of computer games to learning. Threats are in our opinion bound with the physical limitations of the computers and the oppressive nature of the opinions by the ready–made solutions and teachers' unresponsive attitude towards alternative solutions. The display of the computer can be too small and place–bound surrounding to apply our system seamlessly to normal teaching. It is also worth thinking whether the learner can hold up to her thoughts, even when being correct, if she is made to play with the authority's vision of the same matter.

Strengths: • Supports learners with different learning skills and methods • Helps to construct new inner cognitive structures out of the information • Helps to visualize the learner's implicit structures	**Weaknesses:** • Computer usage skills are needed • Learner needs abstract, conceptualized thinking skills
Opportunities: • Helps learners to acquire new learning strategies • Brings tension and excitement to learning	**Threats:** • Learning space is limited to size of the computer's display • The original own ideas might be abolished after seeing the version done by authority, namely the teacher

Table 1. SWOT analysis from the learner's point of view

From the teacher's point of view our system's strengths are especially concentrated on helping the learner–teacher interaction. Concept mapping equips the teacher with a novel medium of evaluating the learning process of her student [7, 3]. The different game types support the teacher to acknowledge the differences between the ways learners learn and build their knowledge structures. The results that learners achieve by using the system help the teacher to understand the level of knowledge acquired by learners. In addition, they concretely visualize the differences of comprehension between the learner and teacher. The achieved results serve also the teacher when self–assessing her own work.

The weaknesses include, as in the learner's case, the need for computer usage skills. It is also worth mentioning that a new tool brings in the need for constructing the concept maps for the concept game system, which can be time consuming. The opportunity, which we considered to be especially interesting, is the excitement and tension of brought to learning experience by concept gaming, which helps creating good learning situation atmosphere.

The threats that we discovered in our analysis include concern over predetermined, closed gaming and the role of the computerization in this setting. We wondered, whether closed gaming would serve too much of rote learning goals. After taking this under closer examination, we discovered that it is possible to include also a support for higher learning elements into simpler game schemes as was introduced earlier in this paper. Another threat is the potential needlessness of the computer to produce this kind of game. We argue that especially game schemes supporting higher learning might be too complicated to realize with a reasonable amount of work and time with only pieces of paper and a pen.

Strengths: • Helps to understand the learners' ways of learning • Helps to see the amount of knowledge adopted by learners • Helps to understand the differences between own and the learners' comprehension • Helps to meet the needs of the different kinds of learning strategies	**Weaknesses:** • Work needed for constructing the new maps for different contexts • Computer usage skills are needed • Computers are needed in the learning situation
Opportunities: • Learning experience can be exciting, thus creating good atmosphere in the learning situation • Sharing and exchanging the concept maps • Tool to study the learning process	**Threats:** • Closed game schemes tend to be mechanized, encouraging learner to think in a too straightforward and prepared way, abolishing their own ideas • Some ideas might be realized with pieces of paper and a pen

Table 2. SWOT analysis from the teacher's point of view

5 Concluding Remarks

We feel that concept gaming has potential to become an important learning aid. It has several advantages. A game can be automatically generated from any topic. With concept gaming the learner is able to analyze her comprehension and to learn new contents. Concept gaming supports various, more advanced learning methods in addition to memorizing.

Open gaming helps to develop higher learning methods, especially open problem–solving skills of the learner. As a side effect, we expect that concept gaming will not only make learners more familiar with concept mapping, but they start to apply concept mapping in analyzing and memorizing. After tuning and improving our prototype, we will later on run extensive tests in order to measure the effect of concept gaming on learning outcomes among various student groups.

The concept gaming serves also the teacher in her evaluation process of learner, in her self–evaluation, and comparison of her and her learners' comprehension. We also argue that the data gathered from usage of the concept gaming system, helps both the teachers and researchers in their research of cognitive aspects of learning.

The built–in randomness of concept gaming compels the learner to think of unconventional and even surprising connections. This helps her to better recognize wrong structures and to create novel ideas. Randomness guarantees that the exactly same game occurs very seldom, if the input map is nontrivial.

The design of the user interface is important for this type of game in order to attract students of different ages and backgrounds. We have started a project to test our prototype in a real learning situation in an elementary school in order to improve its usability. Later on we plan to offer an adjustable user interface so that besides the default look and feel, the user is able to change several details according to her liking.

The benefit of concept gaming depends partly on number of the ready–made concept maps available in the format of the system. A web–based database would give additional value and reduce the amount of work that the teacher must do in order to start using the proposed system.

References

[1] Alessi, S., & Trollip, S. 1985. *Computer–Based Instruction: Methods and Development*. Prentice–Hall, Englewood Cliffs.

[2] Ausubel, David P. 1963. *The Psychology of Meaningful Verbal Learning*. New York: Grune & Stratton.

[3] Bykov, V., & Dovgiallo, A. 1997. *Concept mapping towards a tool for active learning*. In: New Media and Telematic Technologies for Education in Eastern European Countries (ed. Kommers, P., et.al.), Twente University Press, the Netherlands, 193–202.

[4] Gaines, B. R., & Shaw, M. L. G. 1995. Concept maps as hypermedia components. *International Journal of Human–Computer Studies*, 43, 3, 323–361.

[5] Goldstein, I. P. 1982. *The genetic graph: a representation for the evolution of procedural knowledge*. In: Sleeman, D., Brown, J. S. Eds. Intelligent Tutoring Systems. Academic Press, London 51–77.

[6] Jonassen, D. H. et al. 1997. Concept maps as cognitive learning and assessment tools. *Journal of Interactive Learning Research 8*, 3/4.

[7] Novak, J. D. & Gowin, D. B. 1984. *Learning How to Learn*. Cambridge, England: Cambridge University Press.

[8] Rautama, E., Sutinen, E., Tarhio, J. 1997. Supporting learning process with concept map scripts. *Journal of Interactive Learning Research 8*, 3/4, 407–420.

[9] Rautama, E., Karvonen, A., Tarhio, J., Turkia, J. *Versatile concept map viewing on the Web*. In: Proc. ITiCSE '01, Innovation and Technology in Computer Science Education, ACM, 2001, 105–108.