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Computer Aided Composing Learning Matrial into Primary Learning Tree

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Abstract: The aim of this paper is to introduce a conception of the automated, robust and reliable composition teaching material into one learning tree, which will constitute the basis for an e-education system. It will be presented a simplified schema of lessons positioning in the Z-plane of the learning tree. Author will also focus on the diversification of difficulty levels corresponding to the particular e-lesson version to be suitable for a certain type of student.

Key-Words: e-learning, knowledge tree, learning material composition

1 Introduction

Not so long time ago new field of knowledge have been invented. It has been called (modern) distance learning [8] (nowadays more commonly known as e-learning). Despite of the fact that it already proved its great usefulness, it suffers from many childlike deficiencies. We can count, among other things, to these drawbacks lack of the coherent vision for learning process accomplishment, practical guidelines to organize consistent learning content [7]. Due to these disadvantages e-learning is being perceived ambiguously and incorrectly implemented in e-systems, which leads to limitation its reliability. Usually, in reality, theory and practice are not on the par, same situation is clearly visible in e-learning theory and its implementations. In e-learning, whole pressure was put on the theory of learning, and there is no restrictions or even practical guidelines present, in field of its technology and implementations, which in many cases has negative influence on newly developed e-systems. Currently, most of the college teachers, government and many schools notice the need of standardization and rationalization this type of teaching. More and more is being told about so called e-education systems.

During the last decade necessity of education, that facilitate gaining new abilities in IT and High Tech related professions, was exposed. The job market situation constantly changes; this state enforces constant skill improvement and also people retraining whose jobs are being replaced by automated processes. A lot of universities create new educational services based on different e-learning solutions. This situation resulted in growing interest of jobless community and youth toward alternative forms of learning. This form of teaching, when well organized, gives new undisputed opportunities for many social strata.

Poland wants to make up for the educational lacks by the utilization of distance learning techniques. In early 2006 suppose to start, brand new teaching program created especially for e-learning solutions. Probably first students start gaining their knowledge in a year from now. This program is part of the actions, which were written in document called "Strategy for persistent education progress until year 2010". Aim of this strategy is to compensate differences in youth education. The government wants raise the level of education of Polish society.

Program called "ePoland - a strategy for informational society development in Poland for years 2001-2006" prepared by Ministry of Education and Ministry of Economy include among other given below goals [2]:

- Making aware teaching personnel about e-learning,

- Adjusting teaching programs for e-education, based on common equipment (e.g. home computers),
- Utilization e-systems in parallel as legitimate form of teaching,
- Creation e-learning systems wherever it is necessary and possible.

Teaching efficiency is the function of forms and methods multiplicity, and educational purposes [5]. Increasing efficiency could be only done by the proper organization of the teaching content and also accurate teaching materials delivery [9].

In the classical learning schema (non computer aided), a teacher or a tutor, on the base of his teaching experience, expertise in a field of knowledge and intellectual or/and or abilities, decides steps in teaching process. In e-learning, a computer must takeover all the decision.

Most of the problems that occur during e-system utilization are cause by the inappropriate preparation and design of learning material [8]. There are only few e-systems that were built in accordance to common sense idea that each student differs, usually in significant way, from another [4]. If we have tried to teach all students in real world in same manner, it would brought us unpredictable (read: unsatisfactory) results. That is the reason why we should really focus on a differentiation of teaching material [6].

Entire paper will be devoted to the principles, how to exploit computer resources to create from a scratch primary learning tree which will constitute the basis for the future computer aided e-learning system. Aim of this paper is to introduce conception of the easy, robust and reliable computer aided composition teaching material into one learning tree, which will constitute the basis for the computer aided e-system. It will be also presented a simplified schema of lessons positioning in the Z-plane of the learning tree. Author will also focus on the diversification of difficulty levels corresponding to the particular e-lesson version to be suitable for a certain type of student.

2 Assumptions and Definitions

In this paper author makes the assumption that all students which take part in learning process have their individual (obviously, some individuals could have the same) Level of Knowledge (LoK). LoK can be changed during learning process, and it's being determined either by a computer algorithm or by a human tutor, before one takes part in e-learning. LoK must be known or determined in order to adjust appropriate learning material that suit student's intellectual profile. The model of the student is not the subject of this paper; since it won't be discussed here.

Course material (that is comprised of e-lessons) will be called a collection of data, prepared previously by a bunch of the field experts) which contains text, equations, pictures etc. Course material will be organized in Primary Knowledge Tree, called referral digraph [1,3], with three dimensional, hierarchical structures (an additional dimension is e-lesson difficulty variant). Graph vertexes are the smallest portions of knowledge (course lessons), which can be learned by a student. Each graph vertex (knowledge quantum) is connected with the following one (situated lower in hierarchy), which contains more comprehensive information / data than previous one, concerning factual knowledge, not only in quantitative sense, i.e. higher situated vertexes, consist of more general knowledge than lower ones. The lower nodes are connected with more detailed and specific information / knowledge.

Edges of the graph indicate dislocation direction thru the referral digraph (knowledge tree).

Considering separate graphs (and omitting third dimension - the depth), we deal with classical referral digraphs, which will be transformed after the process of overlapping, into 3D Knowledge Tree called Primary Knowledge Tree (abbr. PKT). Looking at the Primary Knowledge Tree, after overlapping process, one may notice that each vertex (which is in fact an e-lesson) could have more than one "equivalent" in Z-axis. This equivalent will be called e-lesson difficulty variant [d_{fact}]; therefore third dimension is a difficulty factor of particular e-lesson [$l^{(i)}$]. Difficulty variant of e-lesson should be interpreted as follows: the easiest lessons are always located the closest in Z-plane to the observer. Further from observer are located more difficult variants of e-lesson.

In order to pass to the next vertex (e-lesson) student must pass (score minimum number of points in the competence test) the easiest difficulty variant available.

By analogy to the classical learning, difficulty variants, can be compared to the set of exercises that concerns same field of knowledge (its part), which should be mastered to pass to another topic. There are exercises with different difficulty levels, in the exercises books, which can chosen by the student with a particular skill factor. Each e-lesson comprise of:

$$l^{(i)} = \left\langle variant(d_{fact})^{(z)}, test(d_{fact})^{(z)}, pts(d_{fact})^{(z)}, dec\_element \ldots \right\rangle$$

Where:
variant(d_{fact}) - represents e-lesson difficulties variants,
test(d_{fact}) - represents competence test (to pass after each e-lesson),
pts(d_{fact}) - number of credit points to score,
decision_element -makes decision on which level move individual in next lesson.
The e-lesson location in a knowledge tree, can be established by means of three coordinates:
x - location in horizontal plane (starting from the left)
y - location in vertical plane (starting from the tree root)
z - depth, towards Z-axis, it symbolizes lesson difficulty factor; the most outer lesson has 0 difficulty level and represents learning material designed for students with the lowest knowledge level.
We need take into account that learning tree ought have a proper form, and accept given below, assumptions to carry on further discussion;

- Tree root should be located on the top of tree,
- Learning process (usually) starts from the top, basics and elementary portion of particular field of knowledge are located closest to the top,
- Going down to the tree crown, lead the edges, connected with more compound lessons,
- Each vertex should have more than one version of the e-lesson, which is arranged along Z-axis; the simplest lesson is situated closest to the coordinate system (closest to the observer).

3 Description of the Algorithm

Now, having the definitions and assumptions defined we may proceed to the description of the Primary Knowledge Tree composition. In order to start tree composition, one has to gather group of experts from chosen field of knowledge (Fig. 2 / Block 1). Optionally we divide these experts into groups (Fig. 2 / Block 2). Each expert (or group of experts) ought to prepare his own set of lessons (Fig. 2 / Block 3) [step ends when groups create all lessons set], taking into consideration that in next step lessons should be tied together to create logical structure (Fig. 2 / Block 4) in a manner that starting lesson should be as general as possible, and the following ones, one by one, should contain more comprehensive information / data than the previous one. This logical structure is the result of consultation between experts, and must be agreed jointly. It may happen that groups may have diverse opinion about lessons order. Without common agreement, about lessons order, further steps might be impossible (Fig. 2 / Block 5) [this being done until all lesson are not incorporated into graphs]. After that, with support of graph expert and computer software (Fig. 2 / Block 6), all these lessons should form one referral digraph for each expert group. At this point, we have received several graphs, each from one expert / group. Overlapping all graphs altogether, one on another creates Primary Knowledge Tree. But we need take into account that lesson from expert n needn't be in each step exactly the same level in plane Z. Following experts' consultations influence on the position definition in plane Z. This usually lead to the situation, that individual lessons that come from one expert, are not classified in the following steps on the same difficulty level, and not located on same position in plane Z. "Depth" of each lesson in Z-plane, in Primary Knowledge Tree is strictly dependent on the lesson complexity (called difficulty factor or difficulty variant). Refer to the Simplified schema of vertex positioning in the Z-plane (Fig. 1) that facilitates solving this issue. This concludes construction of the Primary Knowledge Tree.
Process of the digraph transformation (Fig. 2 / Block 7) into the Primary Knowledge Tree could be easily automated. We assume that experts returned estimated difficulty of each lesson (as an integral number).

```
for each of vertex
    for every digraph
        get all e-lesson_difficulty_factor
        store e-lessons_difficulty_factor
    sort ascending by e-lessons_difficulty_factors
    return order_of_lessons in vertex of Primary Knowlegde Tree
proceed to next vertex
```

Fig. 1 Simplified schema of vertex positioning in the Z-plane

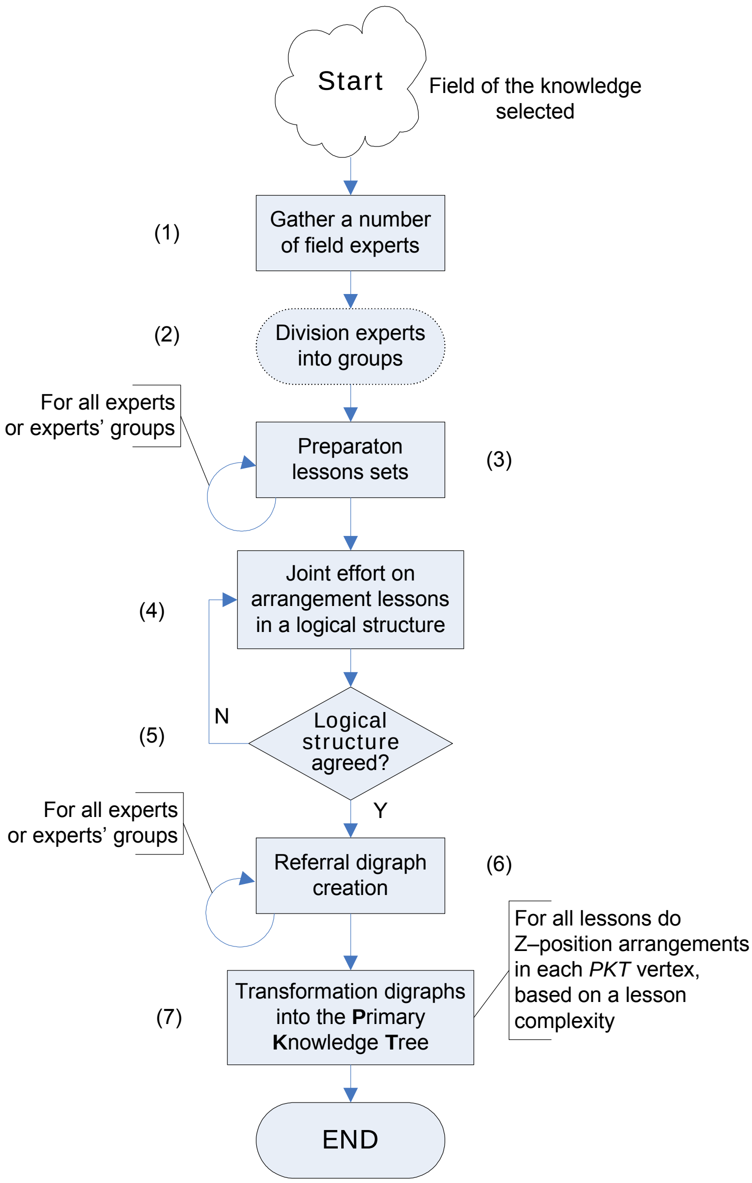

Fig. 2 Creation of the **P**rimary **K**nowledge **T**ree - steps of the algorithm

Path [n][m]	[1]	[2]	[3]	…	[12]	…	[m]
[1]	Vertex cords	Vertex cords	Vertex cords				
…	Vertex cords	Vertex cords	Vertex cords	Vertex cords	Vertex cords	Vertex cords	Vertex cords
[n]	Vertex cords	Vertex cords	Vertex cords	Vertex cords	Vertex cords		

Fig. 3 Sample learning paths' table

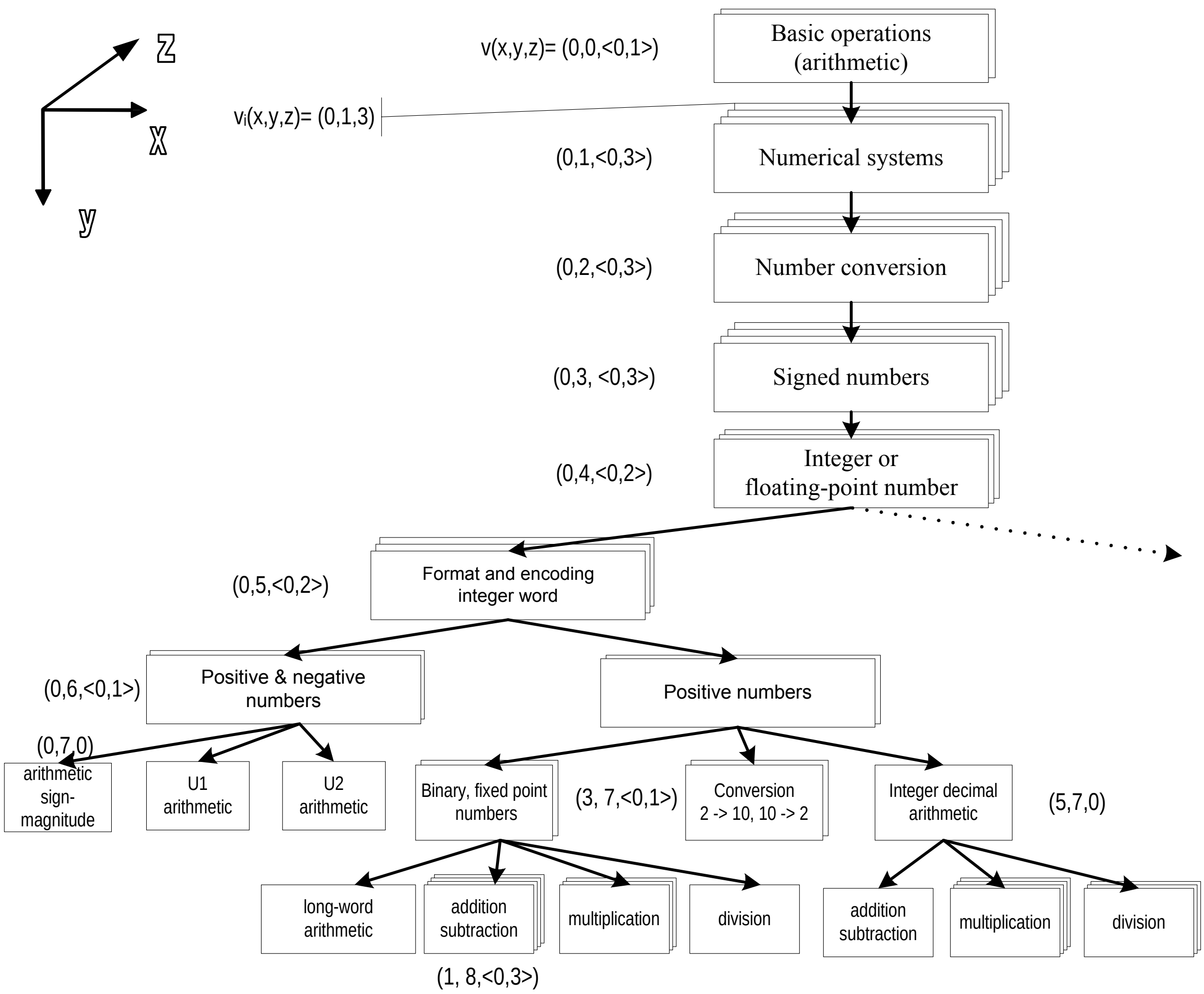

Fig. 4. Sample **P**rimary **K**nowledge **T**ree

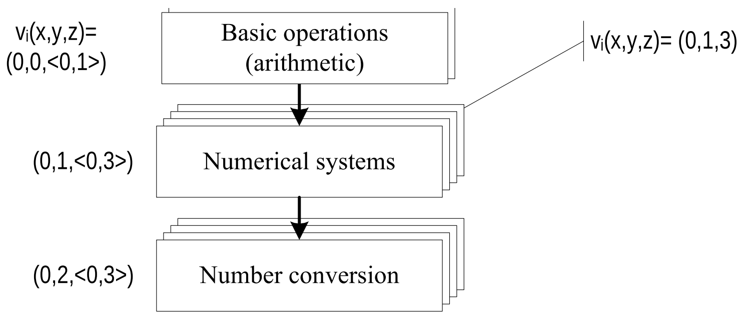

Fig. 5 Fragment of the sample **P**rimary **K**nowledge **T**ree

When the Primary Knowledge Tree (Fig. 3.) is built, it could be handy to split its branches into ready-to-use learning paths. By the learning path, one can assume chain of the vertexes (e-lessons), which passed, one by one, by a student, assure that certain fragment of material had been taught.

Division into branches is also being done with the help of the experts. All possible paths learning will be stored in the database and during learning process some of them will be loaded in the computer memory as a table with learning paths (Fig. 3.). Due to the fact, that some of the paths are subset of the others, there is no problem to utilize shortened version, if applicable.

Let's consider Primary Knowledge Tree fragment like on the Fig. 5:

$$v_i = \begin{cases} x = 0 \\ y = 2 \\ z \in < 0, 3 > \end{cases}$$

It's easy to notice that it has four difficulty variants and it is a second lesson from the tree root.
Learning sequence of the students group, in e-learning course, is being delimited by the learning paths (described in details above) which are only way of the navigation thru the PKT. These paths could be perceived as sub-graphs, which passed by the students, assure that certain branch of the material has been learnt. Combinations of the following lessons, which are taken from the PKT, form learning paths.

Rejection, by the experts' digraph branches and leaving difficulty variants only, results in receiving learning paths.
It is worth to mention that the difficulty variants are being utilized for lessons assignment for students' intellectual profiles, which is being done by the adaptation algorithms (not described in this paper).

4 Conclusions

Growing need of the learning process diversification, among educational institutions, influence on creation new methods to support learning. Surrounding technical resources like computers and peripherals could vastly improve those techniques. E-learning is unfortunately not normalized and usually its utilization arises many difficulties, and sometimes causes more damage than good. Utilization existing teaching methods and exploitation learning materials is rather difficult especially for the non technical experienced persons. In order to support all the efforts towards e-form of learning utilization with exploitation of computer resources, the conception of composing learning content into Learning Tree was presented. We aimed to create simple and at the same time consistent transformation human knowledge into computer system. It is common knowledge that computer (algorithm) takes over knowledge delivery / teaching process in e-learning system and without solid and reliable basis in form of a learning tree, these will be handicapped or won't possible.
Presented method of dealing with learning material allows for easy and reliable transition from classical form of learning into computer aided e-form. Described algorithm, which creates the Primary Knowledge Tree, let constitute the solid base for a newly created e-learning course. Proposed method takes into consideration the differences in students education level (so called Level of Knowledge), which greatly improves aligning difficulty level to student ability to accommodate knowledge.
By having such a mechanism, like described in the paper, one can greatly improve reliability (by means of defined and easy to reproduce algorithm steps) of the course content and shorten the preparation of the entire e-learning course. Empirical tests has proven that computer implemented algorithm of composing learning material, can be up to 5 to 12 times faster than non-automated one. What's more, number of technical people involved in LOK creation can reduced from 3 to 1 (subject and material size dependent).

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