Forming Cliques of Collaborating Distance Learners

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Abstract: - Collaborative learning is one of the most promising applications of information technology into distance learning. Probably, the most important parameter of collaboration is the proper formation of groups of learners. This paper presents a method for collaborative groups formation, based on learners' previous assessment. It utilizes task analysis to model the knowledge fields and calculates a simple similarity metric among students that finally leads to a group formation scheme.

Key-Words: - Education, Distance Learning, Collaboration, Combinatorial optimization

1 Collaboration

Collaborative learning is a social, constructive process, depending on rich contexts, whereas learners bring multiple, diverse backgrounds and learning style preferences [15]. It occurs when learners somehow work together to accomplish shared learning goals [6]. We will use the terms cooperative learning and collaborative learning interchangeably in this paper, as they both refer to some kind of educational experience where learners work together towards a common intellectual goal.

Although the notion can be traced back to the 19th century, it is the modern constructivist learning theories, that have brought it in the foreground of research, making Cooperative Learning one of the best researched areas in education [4]. According to researcher R. E. Slavin, "Cooperative learning is one of the greatest success stories in the history of educational innovation". Collaborative or Cooperative learning is defined as the instructional use of small groups to help students work together in order to maximize their own and one another's learning [5]. Cooperative learning presents the principles and strategies for enhancing the value of student-student interaction [4].

A collaborative classroom has certain characteristics [16]: knowledge and authority are shared among teachers and learners, teachers are acting as learning mediators. Self-regulated learning is essential in collaborative classrooms. Groups, as networks of human relations, are effective if members are cooperating with each other efficiently.

Although Web courseware systems have reached a level of maturity, they still encompass very few, if any, mechanisms to facilitate student control and adaptivity, as constructivism demands [2]. Among various adaptation techniques, collaboration is a key component in the distance learning scenery of the near future: there is a need recognized to extend learner-centered approaches to "learning team centered" approaches [7].

This paper presents a method for collaborative groups formation. Next Section presents the major traits of group formation and argues that the most important criterion for group member selection is the learners' previous performance and assessment; section three uses Task Analysis to model the knowledge fields and a vector space model to present learners, leading to group formation; finally some final remarks are drawn in section four.

2 Group Formation Traits

It is clear that one of the most important parameters of collaboration is the proper formation of the groups of learners. All methods used to allocate members into groups were initially designed for the traditional classroom collaborative environments and most of them fall into four categories [3]:

-- Random Appointment: a teacher selects randomly the group members;

-- Self Selection: students are asked to put themselves into groups;

-- Task Appointment: groups are formed based on students' choices from a list of offered topics;

-- Selective Appointment: groups are formed based on certain criteria.

In the latter case, collaborative teams are usually selected in a manner that distributes students into different groups based on ability, strengths, achievement, experience, gender, ethnicity, different learning or some other characteristic, depending on the purpose of the assignment [8]. A large variety of properties has been used for Collaborating Group formation and can be found in literature [1].

Computer Supported Collaborative Learning seems to be one of the most promising trends of using information technology in education [9]. Yet, this will not occur in a straightforward manner: well trained teachers and proper instructional strategies are needed. In a contemporary e-learning environment learners do not necessarily communicate face-to-face with each other. With the exception of blended learning, learners may just 'meet' online, in 'virtual classroom' [12].

Additionally, as S. Seufert indicates, the concept of online communities has been discussed in almost every field, the field of education included. Furthermore, the online communities are connected with knowledge management and organizational learning, thus integrating learning and working into lifelong learning.

As a result of this integrating tension [13], there is a continuously growing interest in using competencies [11] for designing tailored learning experiences.

As distance learners hardly get into physical contact, characteristics like gender, nationality, age, shyness, religion, color, etc are of less importance than they are in the case of classic classroom collaboration. On the way towards a competency-based learning model [17] in a distance learning environment, the most important criterion to form groups is the pre-existing background knowledge and skills of each learner. Although most web based educational systems collect large amounts of information from tracking the students' actions, this information is not widely used by instructors mainly because it is provided in an unprocessed, poorly organized form [10]. Moreover, Mazza & Dimitrova [10] argue that these systems do not provide information about the original learning outcome that is achieved by student on particular concepts.

Obviously, the most simple and natural way to measure learners' previously gained knowledge and performance on particular concepts, is their past assessment grades.

Adaptive instruction is often performed from analysis of the student's so far performance and a variety of models have been introduced on this subject [8]. But, yet, computer-based Collaborative Learning Systems are in the early pre-mature stage and a lot of work has to be done.

Next section uses Task Analysis to model the knowledge fields and a simple weighted vector space model to present learners, finally leading to collaborative groups formation, based solely on learners' previous performance and assessment grades.

3 Grouping Dissimilar Learners

Robert Gagne's Cumulative Learning Theory has as central idea the learning hierarchies: In order to teach a specific learning objective one must first identify and construct a learning hierarchy for it, which determines the prerequisites for the learning objective. The lower-level tasks must be mastered before higher-level tasks thus making possible to sequence the instruction.

By using task analysis on a complex knowledge field (target), say F, it can be broken down into constituent skills, which compose an m-dimensional information space (Figure 1):

$$F = \{f_i\},\ i \in I^* = \{1, 2, ..., m\}$$

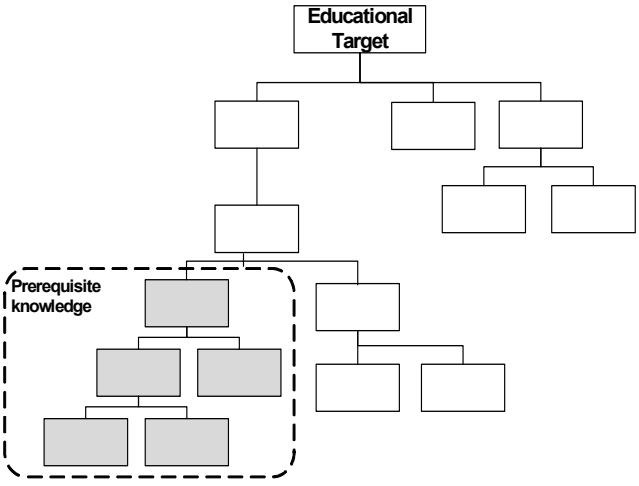

Fig. 1
Prerequisite knowledge defines groups

Let $U = \{u_1, u_2, ..., u_n\}$ be the set that presents the members of the learning community in question.

Let $G \subseteq F$ be the set of skills that are considered as prerequisites to the educational target.

For each learner $u_i, i \in [1, n]$ a vector is defined, presenting his/her performance and degree of knowledge on the various prerequisite skills that belong to the Information space in question:

$$u_i = (u_i^1, u_i^2, ..., u_i^q), q = |G|, \text{ where}$$
$$u_i^k \in [0,100], k \in [1,q]$$

It has been reported that collaborative learning is most value-added when the group members are heterogeneous and the groups are recognized and/or rewarded on an individual learning basis [7].
Thus, heterogeneity is making available a diverse set of viewpoints, ways of thinking and knowledge, while at the same time each learner may be individually held responsible for mastering the learning objectives. Group goals need to be combined with individual accountability in order to promote learning and achieve maximum learners' effort and learning outcome [14].

In order to form the proper groups with heterogeneous knowledge background, we follow the following procedure:

1. Let $\vartheta = 100$.
2. For each pair of Learners u_x, u_y compute the number of relevant dimensions (knowledge items) that their difference is greater than, or equals ϑ. (We consider these dimensions as knowledge dissimilarities between learners).
3. Let S = q.
4. Construct a Graph G with Learners as nodes and edges connecting every pair of nodes that have S or more dissimilarities.
5. Find the maximum clique of the graph G.
6. Remove the nodes and corresponding edges of the clique from G.
7. If G is not empty goto 5.
8. If satisfactory solution found then end.
9. Set S=S-1.
10. If S > 0 then goto 4.
11. Set $\vartheta = \vartheta - 10$.
12. If $\vartheta > 0$ then goto 2 else end.

As it is well-known, the clique problem (CP) is NP-Complete, therefore we don't know any polynomial time algorithm to solve it exactly. Since we are using the CP as core of our process for group formation, we deduce that the presented algorithmic approach is NP-Complete. However, the method is expected to, efficiently, produce the groups due to the following reasons:

- the graphs are relatively small. We are dealing with dividing groups of *learners*, therefore we anticipate to have a total of no more that 50-200 nodes in our graph.
- the method is designed in such a way that the first created graphs are sparse, getting denser as the procedure continues. Since we wish to create *small* groups of collaborationg learners, the solution will be derived in the early stages, within sparse graphs: it is well known that finding the Clique in a sparse graph is much easier than in a dense one.
- there are several well-known methods (and some distributed) for solving it to optimality with good performance. Additionally, one may use heuristics since optimality is not indispensable in our case.

4 Final Remarks

Collaborative team formation is part of Adaptive educational distance learning systems. Collaboration has been intensely studied and used in typical classroom environments.

Collaborative groups formation is done by using several factors and properties of the learners, both academic and non-academic. We believe that in a distance learning environment, previous knowledge is the most important property.

This paper presented a method for forming heterogeneous groups, based on the learners' previous knowledge and assesment. The method uses two major criteria that measure the distance between learners, trying to maximize them in the following order:

- *first*, distance of assesment grades on the several prerequisite knowledge items and,
- *secondly,* number of knowledge items that differ more than a threshold alreadey selected in the first step.

The model is already being under further elaboration. The main research issues include (but are not limited to) the following directions:

- implement and/or adopt a group formation algorithm of complexity lower than the one's used in present paper.
- combine the group formation process with the selection of learning content that is specially suited for each group's/learner's needs.
- application of the group formation method to one or more well-known collaborative learning methods.

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