ORIGINAL PAPER

TOWARD INCREASING LEARNING GROUP CREATIVITY WITHIN COMPUTER SUPPORTED COLLABORATIVE LEARNING

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Abstract. *Creativity is omnipresent in every activity domain. As for the economy nowadays, it needs employees who are adaptable, innovative, creative, flexible, and with teamwork abilities. Therefore, our educational system has to adapt to those new requirements and to stimulate the learners to achieve the desired skills. Fortunately, there is evidence that creativity can be cultivated and that opportunity is ought to be integrated within the instructional processes. In this paper, we propose a model for creative collaborative learning based on both models for group creativity and the basic factors that contribute to development of creativity. Particularly, our aim is to organize learners in teams prone to enhancing group creativity by using classification techniques based on Bayesian Networks. Organizing learners in creative work groups and creation of creative contextual learning environments boost both the creative abilities of learners and their instructional performances.*

Keywords: *Group Creativity, Computer Supported Collaborative Learning, Bayesian Network.*

1. INTRODUCTION

In collaborative learning, the actors of the learning process are members of a group that share and create knowledge, meaning, understanding of both concepts and theories etc. Computer Supported *Collaborative* Learning (CSCL) has appeared as a reaction to software used previously in learning, which have been forcing learners to study and learn as isolated individuals [1]. In CSCL learning is obtained by computer-supported interactions both between learners and between learners and teachers. Koschmann defines CSCL as *a field of study centrally concerned with meaning and the practices of meaning-making in the context of joint activity and the ways in which these practices are mediated through designed artifacts* [2]. In this paper, we propose a method of organizing learners in working groups that undergo a CSCL process, aiming at increasing each group's creativity. This is based on an idea introduced in our previous works [3-4], where learning groups included creativity triggers that influenced each group's creativity. The concept of *group creativity* attracts lately the attention of educational institutions and companies alike. However, is quite challenging to determine in which way the interactions that take place inside a group result in either an increase or a decrease in creative group performances.

In our previous works we have been concerned with individual creativity, namely what are those factors that stimulate creativity, the so-called *creativity triggers*. Here we focus on the concept of group creativity, along with the design of a model that provides for

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development of an automatic system for organizing learners in creative (learning) work groups. Our proposed method consists of the following steps:

- Evaluating the features of each learner that influence group creativity (e. g. the level of creativity, the motivation, the domain expertise and so on);
- Clustering the learners according to the results of the previous step evaluation;
- Constructing the creative groups by grouping equitably the learners based on their influence score for group creativity. We establish the influence classes using Bayesian Network for classification.

The structure of the paper is as follows: the next section, called *Learning Group Creativity*, presents the concept of creativity for learning groups; the third one summarizes some ideas about group creativity models, for instance the *componential theory of creativity* and the *multilevel model of group creativity*; in the following section, called *Model for collaborative creative learning*, we propose a model for classifying users (that uses Bayesian networks) and including them in creative groups; and the last section is dedicated to some conclusions and future work ideas.

2. LEARNING GROUP CREATIVITY

Creativity is a concept highly debated in the psychological literature. Sternberg and his co-authors state that *creativity is the ability to produce work that is novel (i.e., original, unexpected), high in quality, and appropriate* [5]. Trying to understand the concept of creativity and its sources has lead to elaboration of many theories, for instance *the investment theory of creativity* proposed by Sternberg and Lubart [6-7]. According to this theory, creative people are the ones *who are willing and able to, metaphorically, buy low and sell high in the realm of ideas*. Buying low refers to work on ideas that are unknown or unpopular, which have, however, built-in potential for growth. It is quite common that when such ideas are introduced for the first time they may encounter resistance. Nevertheless, a creative person would persist resisting to this opposition, and she will, eventually "sell" high, a new, powerful, or popular idea, achieving this way a *creativity habit* [7]. Group creativity is a recent topic in the literature, which is seen as one of the expression of *the social nature of the creative act* [8]. However, group creativity is more that summing up the individual creativities of the members, as the interactions that take place between them of the group, the diversity of their backgrounds, abilities, and knowledge generate added value in the creative learning process. The importance of interactions between the group members and their role in stimulating creative processes is addressed in [9], where is shown that synergy refers to the added gain of collaboration within the group, which is obtained as a result of the stimulation, both cognitive and motivational, that results from these interactions. Further, based on the theoretical bases of synergy, the authors identify the cognitive, social, and motivational factors that influence the increase of group creativity: exchange of ideas, potential for competitiveness that allow individuals to compare their performances with the ones of their teammates, concept, product and perspective sharing, intrinsic motivation, openness to new experiences, etc. *Creative learning* is concerned with instructional processes aimed at development of creative abilities of individuals. *Collaborative creative learning* approaches learning that results from interactions and collaborations that take place between learners, and that aspire to enhance creativity at both individual level and group level. Group creativity may be improved by providing appropriate contextual instructional environments and by organizing the individual in suitable groups.

3. GROUP CREATIVITY MODELS

Amabile defined the *componential theory of creativity* and the elements that influence creativity [10]. Three of them concern the individual level: *domain-relevant skills*, *creativity-relevant processes,* and *task motivation.* The fourth component is external to the individual: *the social environment.* Domain-relevant skills refer to knowledge and expertise of the individual in a specific field. *Creativity-relevant processes* include individual characteristics that favor creativity: cognitive style, personality traits etc. Internal motivation of the individual is captured in the *task-motivation* component. Moreover, the author points out that *a central tenet of the componential theory is the intrinsic motivation principle of creativity*. The external component, called *social environment* represents the work environment. In addition, the author considers extrinsic factors that either impede creativity or stimulate it. A detailed description of this theory may be found in [10]. For our work, we consider as social environment the contextual learning setting. In his model of group creativity, Sawyer sees creativity as a synergy between *synchronic interactions* and *diachronic exchanges* [11]. In his work about the *multilevel model of group creativity*, Taggar highlights that besides including creative members, team creativity is significantly influenced by *relevant processes that emerge as part of group interaction* [12]. In their theoretical multilevel model of group creativity, despite seeing team creativity as simply cumulating individual potential for creativity, Pirolla-Merlo and Mann explain how creativity evolve over time within teams and the way in which it is influenced by the "climate" of creativity [13]. The contextual factors that influence creativity presented in [14] are divided in three categories: (1) factors that facilitate team creativity (*supervisory and co-workers support, psychological safety, group process*), (2) factors that obstruct the generation of creative ideas (*conformity, insufficient resources, and bureaucratic structure*), and uncertain factors (*team diversity, conflicts in teams, group cohesion*). Within our current work we focus on individual components of creativity when building the learning groups likely to be creative.

4. MODEL OF CREATIVE COMPUTER SUPPORTED COLLABORATIVE LEARNING

In this section, we introduce our model for creative Computer Supported Collaborative Learning (see Fig. 1). First, we evaluate the learners' characteristics that have an impact of group creativity such as the individual level of creativity, the personal motivation, the domain expertise and so on. We continue by clustering the learners based on the assessment made in the previous phase, and, finally, we build the creative teams by fair grouping of learners classified according with their influence score for group creativity. Among the classifying techniques that we could use for this last phase, we mention naïve Bayes classifier, neural network based classifier, decision trees, and support vector machines. For our first experiments, we have chosen Naïve Bayes classifier, which is a probabilistic classifier based on Bayes theorem [15].

A Bayesian Network is a graphic model based on probabilistic directed acyclic graphs that can be used for representing uncertain knowledge. Each node of the graph represents a random variable, whicl the arcs define a probabilistic dependency between variables. These dependencies are quantified by the conditional probabilities between variables. A detailed description of the classification techniques based on Bayesian Networks can be found in [16].

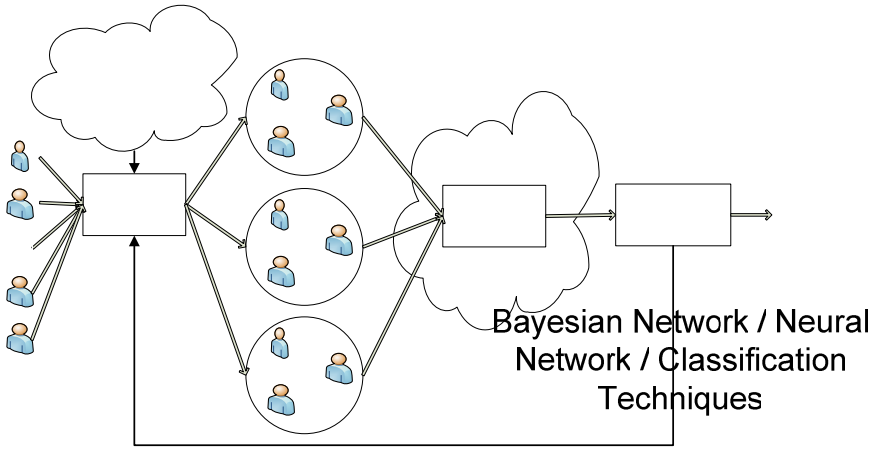

Figure 1. Model of Creative CSCL.

In our current work, we simulate our model using a Naïve Bayesian Network, in which the attributes consist of the contextual factors of creativity, while the classes correspond to the learners categories with respect to their contribution to group creativity (Fig. 2).

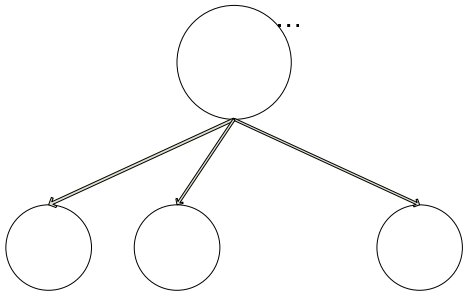

Figure 2. Naïve Bayes Classifier.

We consider three classes of learners with respect to the influence of individual creativity contribution to the group creativity: A (high), B (medium), and C (low). The set of attributes taken into account here contain the level of creativity, the domain expertise, and the individual motivation. The level of creativity may be established using various tests such as tests of divergent thinking, creative personality, etc. A well-known test that is also easy to use is Creative Personality Scale (CPS) Gough's, which output is in a range between -12 and 18. The domain expertise is captured by the grades obtained by learners at previous specific test, ranging from 1 to 10. The intrinsic motivation level is evaluated using a questionnaire, which may result in 0 (low motivation), 1 (medium motivation), and 2 (high motivation). The used Bayesian Network learns, starting with a training data set, how to determine the influence class of each learner with regard to the group creativity. From the training data set, the classifier determines the conditional probability for each attribute of each individual pertaining to a certain class. Then, by applying the Bayes theorem, the probability of falling within one class for a given set of attributes is computed. The class with the highest posterior probability is the predicted class (Fig. 3).Bayes's Theorem can be used to calculate the probability that some elements pertain to a group:

$P(h|D) = P(h)\,P(D|h)/P(D)$

$P(h|D)$ = the probability of h conditioned by D

$P(h)$ = the prior probability for h hypothesis

$P(D|h)$ = the probability of D conditioned by h

$P(D)$ = the prior probability for the training data set

For building the module, the creative groups considers the influence class of each and every learner, and mix the three possible classes (high, medium, low) to generate the creative groups based on a fair distribution algorithm. Within the second phase the learning process

takes place, the creative contextual environment being influenced by the following creativity triggers [4]:

- *Promote the importance of creativity: learners have to be aware of creativity role in the economy and in everyday life;*
- *Include motivation tasks;*
- *Include advising tasks;*
- *Use different instructional strategies (focused on problem-based learning and project-based learning);*
- *Develop social/collaborative skills;*
- *Develop various different teaching/learning scenarios, use critical thinking model;*
- *Allow questions sessions;*
- *Do not over-structure the lessons/lectures;*
- *Keep a balance between learner control and machine control regarding the management of the learning process;*
- *Design multicultural and multidisciplinary tasks;*
- *Include information aggregation tasks.*

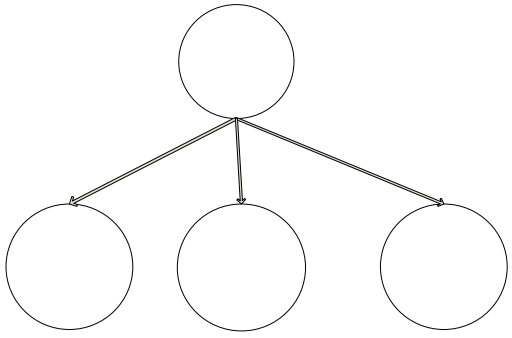

Figure 3. Bayes Network for Learners' Classfication.
$P(C|A_1, A_2, A_3)=P(C)\ P(A_1|C)\ P(A_2|C)\ P(A_3|C)$

A score for group creativity is obtained in the third phase as a result of a teacher's evaluation of the result of the learning process (idea, product, solution etc.) along with the group working approach. The four scales defined in Torrance Tests of Creative Thinking (TTCT) may be used for performing this evaluation [17]:

- *Fluency*: the total quantity of *interpretable, meaningful, and relevant ideas* produced in response to the stimulus;
- *Flexibility:* the number of different sorts of pertinent responses;
- *Originality: the statistical rarity of the responses;*
- *Elaboration:* the quantity of detail in the responses.

The obtained group creativity may be low, medium or high. If the desired level of creativity is achieved than the objective of constructing creative groups have been fulfilled, otherwise, during the next instructional session, the groups will be re-organized.

CONCLUSIONS

The creativity plays a ever growing important role in our society. Teaching and learning systems have to change in order to provide for development of creative abilities of learners. In the current work, we have been concerned with grouping students in creative teams, based on evaluations for both factors that impede or stimulate creativity, which have

contributed to establishing the influence class of each learner with respect to her contribution to group creativity. Rooted in these influence classes, learners have been distributed fairly in various creative groups that offer a contextual creative learning environment.

Future development of the model will include incorporation of various classifiers, comparison between the results, and it will be followed by the implementation of a working prototype able to find the best way of constructing creative groups on-the-fly in a live CSCL environment.

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