A K-complementarity Technique for Forming Groups of Tutors in Intelligent Learning Environments

Yacine Lafifi, Safia Bendjebar and Amina Zedadra

LabSTIC Laboratory, University 8 May 1945 Guelma, Algeria

In e-learning environments, tutors perform the main function of tutoring. They follow up learners and answer their assistance requests which require different skills. These requests may not belong to the tutors' skills and competencies, so collaboration among other tutors is expected. In fact, this collaboration can improve tutors' skills and provide learners with effective monitoring. It can be permanent and adaptive, according to learners' needs and requests. Grouping tutors with different skills is the aim of this research. In this paper, a new technique for grouping tutors is presented. The proposed technique is called K-complementarity. It is based on the complementarity of roles that are assigned to tutors. K-complementarity is based on tutor model and aims at obtaining K groups of tutors who have the most of the roles and skills. The proposed technique has been used by a Computer-Supported Collaborative Tutoring (CSCTT) system. This system had been tested in an Algerian University. The obtained results showed that the groups' members are heterogeneous and the groups are homogeneous. Furthermore, each group had more than 80% of the roles by combining those of its members. So, these results can be considered as acceptable and very encouraging.

Keywords: forming groups, collaborative tutoring, K-complementarity, tutor model, complementarity coefficient, intelligent learning environments

1. Introduction and Motivation

Tutoring is a human activity, which has been applied in several fields. In the educational field, this task has become indispensable, especially in higher education institutions. The primary objective of tutoring is to support the learners throughout the learning so that it fully reaches the educational objectives set by the educational institution (Peraya, 2011). Furthermore, it aims at supporting all the activities of learners and assisting them to find learning difficulties and problems. In other words, distance tutoring or e-tutoring is referred to all the activities that support learners in their learning process (Kopp et al., 2012).

With the development of information and communication technologies, many environments have been implemented to support the educational activities of learners (learning, assessment, collaboration, etc.). Tutoring task was supported by these systems explicitly or implicitly. Indeed, in the majority of these systems, support to learners is provided. This support can take many forms: content and path personalization, adaptive interfaces, virtual or real scheduling meetings, etc. Support process is carried out by a human actor or by an artificial entity (as in the case of Intelligent Tutoring Systems). In Intelligent Learning Environments (ILE), this actor is called: e-tutor (Shaoming, 2011; Kopp et al., 2012). The roles of e-tutors in distance learning are numerous (Decamps & Depover, 2011). Furthermore, this actor has several names: mentor, coach, facilitator, etc.

In the literature, there are many researches that are interesting in learners' monitoring process, which is ensured by tutors (Dolmans et al., 1999; Jelfs et al., 2009; Kopp et al., 2012; Aarnio et al., 2013; Hayashi et al., 2013). We found that there are many difficulties and problems met by both learners and tutors. In fact, learning systems adopting tutoring task in its various forms have some shortcomings. First of all, learners' needs don't belong within the range of tutors' skills (Lafifi et al., 2010).

Secondly, although tutors' roles are multiple, several tutors had difficulties to understand all these roles. Thirdly, the absence of tutors for personal or technical reasons is another problem. Indeed, if learners recognize tutors' intellectual and moral qualities, they often regret their lack of availability (Decamps & Depover, 2011). Followed without the presence of the tutor, some learners have the feeling of being "lost" and "forgotten" on the learning platform and the motivation found quickly affected. Finally, tutors who practice this job for the first time say that it is difficult to understand their roles (Glikman, 2011). So, training task of novice tutors is expected.

Several research questions motivate our contributions. The first one is: how to represent tutors' roles? The aim is facilitating the affectation of tutors to learners and facilitating tutor searching task. The second question is how to improve tutors' skills? The goal is to contribute to the formation of novice tutors on one hand and to benefit from the experiences of other tutors on the other. The last question is how can we measure the improvement of tutors' skills and what is the effect of this improvement on learners' monitoring?

In order to answer these research questions, first, we propose to identify the required tutors' roles. Then, we propose to benefit from the positive effects of collaboration among tutors to meet the requirements of all learners who need help and to improve the performance of tutors, especially the novice ones. In other words, we want to bring together tutors with complementary roles to ensure that each group of tutors has the most of the roles. These tutors work together using communication tools to monitor and guide their learners.

The aim of this research is to propose a new technique that aims at grouping tutors according to their skills and complementary roles. To facilitate this task, each tutor must be represented by a model that has all his features and skills. So, our contributions are particularly related to the proposal of a new structure of the tutor model and the presentation of a new clustering technique of tutors based on complementarity principle.

The rest of the paper is organized as follows. In Section 2, we give some research works dealing with tutors' roles and grouping of users. Section 3 is devoted to the presentation of our new grouping technique, which is the K-complementarity. To validate our approach, a learning system adopting the new clustering technique has been implemented. Section 4 is devoted to present the main objectives of this system. The results of an experiment, which was conducted in a higher-education institution, are presented in Section 5. Finally, a conclusion and future works will be presented.

2. Literature Review

2.1. Tutors' Roles and Tasks

According to Glikman (1999), in distance learning, a few learners seek help on their own initiative. To explain this observation, Glikman evokes different explanations. First, learners can organize themselves to find the information (they need). Then, sometimes they dare not seek help due to the constraint of having to disclose their lack of understanding. Finally, some students do not seek more help because the first contact does not give them satisfaction (Depover & Quintin, 2011). This help can be provided by human actors called tutors. Nowadays, tutoring is becoming an indispensable task for offering help and assistance.

Due to its many advantages, the tutoring task is adopted in many fields: medicine (Shah et al., 2002; Rhodes & Jinks, 2005; Kerridge, 2008; Aarnio et al., 2013, Hayashi et al., 2013), education (Barker, 2002; De Smet et al., 2010; Dillenbourg, 2011; Mangenot, 2011; Porayska-Pomsta & Mellish, 2013), higher education (Weigle & Nelson, 2004; Owen et al., 2006; Xenos & Papadopoulos, 2007; Jelfs et al., 2009), professional training (Li et al., 2012), chemical engineering (Nisbet et al., 2014), management (Cohen-Scali, 2013), library (Waite et al., 2011), etc.

Some researchers argue that in adults' training, the tutor is responsible by his intervention to facilitate the learning process and monitor their activities. His role is that of an accompanying person, coach or resource-person. He should facilitate knowledge transfer and assist the student in his learning personal process and assimilation of knowledge (Glikman, 2002). The four

features which appear are: facilitator, coach, guide, and resource-person. On the other hand, "the primary role of the tutor is to discuss with the learners so that the knowledge they build is used in diverse and varied situations" (Salmon, 2003).

Tutors' roles and functions are mostly specific to each distance learning platform (Rodet, 2008). In most distance courses, the tutor has mainly a psychological and methodological role. Other roles are cited by many researchers: guide, evaluator, moderator, etc. According to (Depover & Quintin, 2011), the function of the online tutor is complex and requires specialized skills in several areas. Indeed, according to Salmon (2000), tutors' skills fall into three main areas: skills related to the management of online exchanges, skills related to the content covered by the course and methodological skills. Other researchers have added administrative aspect or assessment of learning (Bernatchez, 2003; Daele & Docq, 2002).

As a conclusion about the tutors' roles, we can say that there is confusion about these roles from one researcher to another. This confusion is due to the lack of works about the standardization and the instrumentation of the tutors' roles. In other words, there isn't a consensus about the tasks of each role and how to represent each task. So, a modeling user task is required before any research about the instrumentation of the tutors' roles.

2.2. Grouping of Users

There are several researches that are interested in grouping different human actors. Learners are the primary beneficiaries of these works. Indeed, in the computer-supported collaborative learning (CSCL) area, there are several techniques for grouping learners into small groups. These methods have been applied for a long time in the schools of North America, for example. Jigsaw is the most commonly used method. It is based on grouping learners into small groups with a distribution of tasks assigned to each one of them (Tuparov et al., 2009). In fact, in Jigsaw method, each team is formed of four learners (or three in small groups). Participants will share their knowledge and collaborate for developing a common product.

The grouping of human users for various reasons has been studied by several researchers. Lappas and his co-authors (Lappas et al., 2009) proposed an algorithm to form teams of experts in social networks. To do any task, the authors proposed a technique for forming a team of experts having various skills that are required for this task. Furthermore, the proposed algorithm optimizes group size and communication cost between its members.

Forming groups of users in real-time to do unknown tasks has been studied by many researchers. Reviewing articles is a task that requires the formation of groups of reviewers to do a specific task (i.e. evaluate a scientific paper). Anagnostopoulos and his co-authors (Anagnostopoulos et al., 2012) proposed an algorithm to form groups of experts in social networks to decrease the costs of coordination among members. These authors proposed algorithms to be applied online or off-line.

As it was mentioned before, many researchers have studied different ways for grouping learners. Grouping process can be manual or automatic, and it can be carried out by teachers or tutors. Furthermore, it can be performed by the system, which takes into account learners' preferences, their cognitive levels or their learning styles. Deibel (2005) proposed to form groups of learners for increasing interaction during class work based on learning styles.

Other techniques and technologies can be used, such as classification (Zakrzewska, 2008), multi-agent systems (De Marchi et al., 2009) or interaction traces. In fact, the grouping of learners may be done by using their traces via a synchronously/asynchronously communication tool. For example, Shi and her colleagues (Shi et al., 2009) have used forums to form learning groups based on their behavior.

Group size differs from one system to another, and it is a principal criterion for forming groups. Many researches were done on small groups. However, with the emergence of social networks in the last decade, there are many researches that focus on large groups (Legras & Tessier, 2003).

About collaboration among teachers, it aims at designing the learning content (learning objects,

courses, etc.) collaboratively. Indeed, collaborative process is carried out during the preparation of a course's content. In the computer-supported collaborative work/learning field, some researchers have studied the effects of collaboration among teachers. Lafifi and Touil (2010) proposed a collaborative authoring system that supports the collaboration of teachers during collaborative editing of learning objects and exercises. In addition, Hernández-Leo and her co-authors (Hernández-Leo et al., 2006) have developed an authoring tool that can be used by teachers (i.e. Collage). Using social networks platforms teachers can collaborate in order to co-edit learning objects or design solutions. In this sense, Hernández-Leo and her colleagues (Hernández-Leo et al., 2011) proposed LdShake, which is a web tool for social sharing and co-edition of learning design solution.

To our knowledge, there is no work that has studied the collaboration among human tutors in e-learning environments. This is mainly due to difficulties in modeling tutor on one hand, and taking into account the tutors' activities and coordination process on the other hand. Collaboration among tutors can solve several problems, including those discussed in the previous sections. In fact, tutors can share their experiences with others who are not experienced, especially novice ones who always need training for this profession. Absence of tutors for technical or professional problems can be overcome through the collaboration among them. In addition, learners can get many answers to their queries. Finally, several methods and tutoring styles can be used by different tutors belonging to the same group, which is considered as an added value of such systems.

In the next section, we present our new technique, which is based on the use of complementary skills of the tutors belonging to the same group.

3. Principles of K-complementarity Technique

3.1. K-complementarity Applications

The problem of grouping users according to the complementarity feature can be applied in several areas. The first area may be human resources management. The primary goal is forming groups or teams with complementary roles to set up or manage projects where collaboration is required.

Another area of application of this method is agriculture or agronomy. In fact, we can take advantage of this feature (i.e. complementarity) to get new species or animals.

In the military field, we can use the complementary technique to form groups of soldiers with complementary skills to compose ideal groups (including soldiers with most skills).

In the educational field, we can use complementarity to form groups of learners, teachers, tutors, designers, developers, etc. In collaborative learning, learners with different cognitive levels and skills can be grouped to form homogeneous groups. Teachers, in turn, can be grouped together to benefit from the experiences of other group's members in courses and exercises preparation. In fact, K-complementarity technique can be used in the case of the co-edition of courses and/or assessment exercises by a community of teachers having different competencies and skills. The tutors can collaborate to carry out their tasks of monitoring and supervising learners. This collaboration is taken into account by CSCTT (Computer Supported Collaborative TuToring) systems (Lafifi et al., 2012).

Finally, K-complementarity technique can also be used in an emergent field in technology-enhanced learning, which is the MOOC (Massive Open Online Courses). Indeed, MOOCs are considered as one of the main educational trends in the last years (Daniel, 2012; Hyman, 2012). As it is mentioned by Boyatt and his colleagues (Boyatt et al., 2014), the MOOC allows free participation to large numbers of learners from any geographical location. Furthermore, MOOCs are deployed in platforms that offer a set of services for supporting and managing the massive amount of learners (Alario-Hoyos et al., 2013). These learners require help and assistance during their pedagogical tasks in the MOOCs. In this case, tutoring task can be done by organizing tutors in groups having complementary roles. The aim is to answer most of the learners' requests and decrease the efforts of tutors.

3.2. K-complementarity Technique Description

The aim of this section is presentation of the general description of K-complementarity technique. It can be adapted to solve our problem, which is the formation of tutors' groups who have complementary roles and skills. So, the first step to take into account is identifying the tutors' roles to be adopted and used. The second step is proposing a tutor model to be used in the grouping process.

In our case, each tutor is represented by a vector having as size t (number of roles to use). The K groups that are obtained after the grouping task should have the majority of roles by merging the roles of tutors forming the same group.

We can express the K-complementarity problem as follows. We suppose that we have n users having each one t skills. Each user is modeled by a vector which has t elements. We want to get K groups, so that each group's skills are complementary. Each group is defined by a coefficient (between 0 and 1), which is called the *complementarity coefficient*.

We can formulate the problem as follows:

- *Input*: n vectors (representing the profiles of n users), m (size of groups).

- *Output*: K groups. Each one of them has the majority of roles, which are complementary.

For each group, we use a complementarity coefficient, which measures the degree of complementarity in each group. The closer this coefficient is to "1", the more complementary the group is. When this coefficient is equal to "1", the group is called "full complementarity group".

We suppose that we have n vectors having t elements. The value of each element can be "1" or "0". The rule used to calculate K is the following:

If n mod m>=1 then K:=n div m+1 else K:=n div m (with m>=1);

The coefficient of complementarity is calculated as follows:

$$\text{Coef}(i) = \frac{\sum\limits_{j=1}^{t} \left(\left(1 - \frac{(\sum\limits_{p=1}^{m} T_{pj}^{i}) - 1}{m} \right) * \max_{p=\overline{1...m}}(T_{pj}^{i}) \right)}{t}$$

with:

$\text{Coef}(i)$ is the complementarity coefficient of group i.

T_{pj}^{i} is the value of the element j of the vector p of group i.

$\max_{p=\overline{1...m}}(T_{pj}^{i})$ is the maximum (0 or 1) of the elements having position j of all the vectors of group i.

4. Application of K-complementarity in a CSCTT System

To test and validate the formulas of K-complementarity technique, we designed and implemented a computer supported collaborative tutoring system, called TutClass (**Tut**or **Class**ifier). This system allows grouping tutors into small groups using K-complementarity method. It provides collaboration among tutors to satisfy all learners' needs; it improves tutors' skills, and it contributes to the training of new tutors in this job. Furthermore, it can be used by any educational institution adopting tutoring activity.

TutClass provides the users with some services like those of an e-learning system (learning objects downloading, assessment activities, etc.). Furthermore, it can be used by many students from different levels. In the actual version, only the students of the license regime can use the system.

The students found two main sub-systems: a learning management system and a tutoring system. They can download the learning objects according to their knowledge level, carry out some learning activities, resolve some exercises prepared by teachers and request the assistance of their tutors.

The main goals of TutClass are: encourage collaboration among tutors, provide learners with tutors having a good number of roles, provide

tutors with much information about their learners, provide tutors with a private space requesting the assistance of their colleagues of the same group and facilitate the collaborative work, following up all traces of tutors and learners and grouping tutors using different methods.

4.1. Modeling Tutors

The K-complementarity technique can be adapted to solve the problem of composing K groups of tutors. Each tutor is defined by his model that has cognitive and tutoring profiles. The tutoring profile includes all the roles assigned to tutor.

For modeling our tutor, we decided to identify his roles. In the literature, we found many roles of the tutors without any classification. After six months of research, we decided to take fourteen roles. The lecturer can read (Lafifi et al., 2010) for more details about these roles and the main confusion made by many researchers about the tutors' roles. The main observation that we can quote is that each author or researcher has his point of view about the functions and the roles of the tutors. Furthermore, many authors used the same name, but with different functions. As a result, we made a taxonomy which can help the researchers to better understand the roles of tutors (see (Lafifi et al., 2010)). This taxonomy is used by a system called LETline (http://www.labstic.com/letline/).

In LETline system (Lafifi et al., 2010), fourteen roles were used. Initially, we thought that offering a lot of roles helps the tutor in his task of monitoring learners, but we noticed that many tutors had problems, especially the novice ones. In fact, after testing this system by real students, we found some difficulties. First, the students don't understand many roles of their tutors. Furthermore, the novice tutors don't understand some functions of some roles. The number of roles was judged as high by both students and tutors. Some students and tutors show that there are some overlapping functions of the tutors' roles. Finally, the interviewed tutors felt that there were redundant tasks in these roles. In addition, they expressed difficulties to understand and identify the tasks of each role.

So, we decided to eliminate some of these limits. To do this, we have worked with experts in cognitive psychology to reduce this number and keep only the essential roles and tasks. As a result, we kept nine roles (Pedagogue, Administrator, Coach, Evaluator, Supervisor, Facilitator, Organizer, Moderator and Psychologist). All the functions that can be carried out by the tutors belong to one of these roles.

Our goal is to form groups of four tutors in each one (the ideal size for a group according to several researchers in computer supported collaborative learning-CSCL-). Each tutor is represented by a Boolean vector (indicating role assignment or not) of size nine (number of adopted roles). We remember that grouping process is done by the complementary roles to make sure that each obtained group has the most of the roles.

In TutClass, tutoring profile of a tutor is represented by a vector of size nine. Each element of the proposed vector can take the value "1" for a role assigned to the tutor and "0" otherwise. To fill this vector, we used a questionnaire designed for this purpose (see Appendix 2). This questionnaire has a set of questions whose answers are used to determine the roles of the tutor. This questionnaire is established in collaboration with a team of experts from Guelma University. Other techniques can be used, such as data mining techniques or self-assignment process. In fact, there is a PhD research work in the LabSTIC laboratory that uses another method for initializing the tutor model without the questionnaire (Bendjebar & Lafifi, 2013).

To initialize the tutoring profile of the tutors, they must complete a questionnaire about the existing roles. The assignment of roles is made according to the following procedure:

- Each role is defined by a set of questions.

- The tutor has the choice to answer by "yes", "no" or "maybe".

- Calculate the percentage of answers of the questions that are related to each role.

- A role is assigned to the tutor if the percentage of his answers is greater than a pail (for example 50%).

For better explaining the tutoring profile structure, we give the following example. The tutor who has this profile is a pedagogue, a coach, a facilitator and an organizer. It will be better for him to work in the same group with the tutors who have other roles, such as administrator, evaluator or supervisor.

Pedagogue	1
Administrator	0
Coach	1
Evaluator	0
Supervisor	0
Facilitator	1
Organizer	1
Moderator	0
Psychologist	0

4.2. K-complementarity Based Algorithm for Grouping Tutors

The algorithm used for grouping tutors, which is called incremental complementarity algorithm, allows to create groups by incremental process. The steps taken by this algorithm are:

- *Step 1:* After initializing tutors' profiles, the algorithm takes a tutor **i** at random (represented by a vector T_i). Then, it puts the tutor **i** in the group G_l (initially $l := 1$).

- *Step 2:* Search for a vector T_j (representing a tutor j) that has a complementary profile to the profile of T_i. Add the tutor j in the same group of the tutor i (G_l).

- *Step 3:* Calculate the union profile, which is obtained by using "or" operator: $T_i := T_i$ "or" T_j.

- *Step 4:* Repeat from **Step 2** until **m** tutors (four in the case of TutClass) in the group G_l.

- While there are unassigned tutors, increment the number of groups (i.e. $l := l + 1$) and repeat from *Step 1*.

- If the last group has a single tutor, then he belongs to the first group.

In other words, the algorithm fetches vectors (i.e. tutors) that are complementary. It takes the first vector. Then, it searches for its complementary vector (or the closest one) from the other vectors in order to add it to the same group, and so on, until obtaining **m** vectors (i.e. tutors).

We remind the readers that our goal is to get homogeneous groups whose members have complementary roles. In other words, it minimizes the distance between groups and maximizes it within the group.

The pseudo code of this algorithm is represented by Algorithm 1 below.

This algorithm uses a function that has as input a vector and as output its complementary (i.e.

Algorithm 1: Incremental complementarity algorithm

Input: n tutors (each tutor **i** is represented by a vector T_i)
      m (size of tutors' groups)
Output: K groups
Begin
I= 1;
Repeat
   Choose randomly a tutor **i** (represented by a vector T_i)
   Put the tutor **i** in the group G_l
   j= 1;
 While (j<=m **and** there is a tutor not classified) **do**
   T_s =**complementary(T_i)** {Search for a vector T_s (representing a tutor s) that has a complementary
                 profile to the profile of T_i}
   Add the tutor **s** to the group G_l
   Calculate the union profile (T_i =T_i "or"T_s).
   j=j+1;
 End while;
l=l+1;
Until l>k;
If the last group has a single tutor **then**
put this tutor in the group G_1
decrease the number k of groups.
End if
End.

T_s =**complementary(T_i))**. The pseudo-code of this function is given in Appendix 1.

5. Experimentation

To validate our proposals, we conducted an experiment at Guelma University (Algeria). This experiment had several goals:

1. Study the feasibility of K-complementarity technique and its adoption in CSCTT systems.

2. Study the usefulness of our vision on modeling tutors and the structure of the proposed model.

3. Extract the benefits and the limitations of our proposals to improve them.

Other objectives are planned, but they will not be taken into account in this paper. They will be the aim of further work.

1. Studying the effects of collaboration among tutors on tutor's performance, and

2. Studying the impacts of this collaboration on learners' cognitive levels.

5.1. Participants

In this experiment, twenty tutors were enrolled online in TutClass. These tutors are teachers and doctoral students. They follow up students from the license regime at Computer Science department ("Information systems" specialty). We keep in mind that tutoring is an accessory task according to the Algerian law (see `http://www.joradp.dz/J02000/2009/001/ F_Pag.htm`, pages 22-23). It can be ensured by teachers or students who have at least the academic Master degree.

5.2. Methodology

Students and tutors could use the system from any computer connected to the Intranet of the university. First of all, the features of our system were presented to all the users. Then, they used the system all the days. At the end of the experiment, two questionnaires were distributed to tutors and learners. The questions were about the system's features and users' appreciation.

In order to validate our approach and especially the K-complementary technique, we proposed to compare it with another algorithm. In fact, our system provides the administrator with other traditional grouping techniques. As it is mentioned in a previous section, providing other grouping techniques is one of the main objectives of TutClass.

The second offered algorithm is based on ordering tutors by using roles' number of each tutor. In other words, this algorithm will classify tutors according to the number of their roles (descending or ascending). Then, it puts in the same group the tutor having the greatest number of roles with those having the lowest number of roles, and so on.

This process is performed in two iterations:

- *Iteration 1*: The algorithm puts the first and the last tutor in the same group, and the second and the penultimate in the same group...until the end of the list of tutors.

- *Iteration 2:* Again, the obtained groups will be ordered. Then, the algorithm applies iteration 1 to get four tutors in the same group. If there is a group with a single tutor, it puts him in the first group.

5.3. Results and Discussion

After using TutClass system, we distributed two questionnaires to the tutors and the learners. The questions in the questionnaires were about the system's features and the encountered problems and difficulties. After the analysis of the answers of the learners and the tutors, and the results obtained from the system, we can confirm that our objectives are achieved and the results are very encouraging.

5.3.1. Study the feasibility of K-complementarity technique and its adoption in a CSCTT system

Immediately after their enrollment, tutors were requested to answer a questionnaire to initialize their profiles. After applying the algorithm, we obtained the results that are listed in Figure 1 with the following parameters: $n = 20$ (number of tutors), $m = 4$ (number of tutors in each group), $t = 9$ (representing tutors' roles) and $k = 5$ (number of groups). For facilitating reading of the results, we mentioned the list

of tutors and the complementarity coefficient of each group.

According to the previous screenshot (Figure 1), we notice that the coefficient of complementarity is between 0.69 and 0.88 with an average of 0.78. Furthermore, the figure shows the time taken to do this grouping.

From the results mentioned above, we see that the group's members are heterogeneous and the groups are homogeneous (each group has eight to nine roles by combining the roles of its members). Therefore, we can say that our target goal is achieved.

For the second algorithm, we obtained the results that are outlined in Figure 2. From this figure, we see that the complementarity coefficient interval is [0.52, 0.83] with an average of 0.67.

Furthermore, all the obtained groups after applying the proposed algorithm contain nine roles (i.e. all the roles). Concerning the obtained groups after applying the traditional algorithm, there is only one group that contains nine roles. Indeed, there are three groups that contain eight roles and one group having seven roles.

From these results, we can deduce that the K-complementarity based algorithm gives results better than the traditional one. The obtained groups contain between eight to nine roles, which is an excellent result. Finally, we mention that 90% of tutors have less than five roles.

5.3.2. Study the usefulness of our vision on modeling tutors and the structure of the proposed model

After the experimentation of our system, we noticed that the majority of tutors expressed their satisfaction about the model's components. However, some tutors found that the questions asked to initiate their profiles are too many. They want to get help for this task. In addition, some tutors wish to find mechanisms to simplify the initialization of their profiles (such as manual assignment or assignment by default). We remind the readers that our proposed tutor model is primarily based on his tutoring profile.

Finally, we can say that our model includes a lot of information that characterize tutors. However, the task of initializing the profiles can be improved. Doctoral work is underway to find other mechanisms and techniques to manage the tutor model.

5.3.3. Extract the benefits and limitations of our proposals to improve them

In the first experiment, we observed that tutors and learners were very pleased with this system and its features. In addition to monitoring function and learners' traces visualization,

Figure 1. Groups of tutors obtained by applying K-complementarity technique.

Figure 2. Grouping tutors using a traditional algorithm.

collaboration activity has been admired by the majority of tutors, especially those who practice the tutoring activity for the first time.

The questionnaire submitted to tutors contains 26 questions. These questions are about the features of the system, the roles and functions of tutors, and the quality of the collaboration among them. For example, to the question: How do you see the effectiveness of the use of the system? 70% of the tutors replied that the system is efficient, 20% that the system is very efficient and only 10% of them replied that the system is not efficient.

The majority of tutors are happy with their teammates. In fact, 80% of the tutors answer the question "Is the composition of the group good for you?" with "yes".

However, tutors met some difficulties and problems:

1. The majority of tutors wanted to have a filtering tool of learners' traces. They noticed that there were many useless learners' traces.

2. The collaboration space has a lot of useless information.

3. Some tutors express the problem of the absence of tutors grouping method according to their affinity.

4. The collaboration tracking tool requires improvement. Some tutors have found many difficulties during its use.

On the side of learners, they appreciated the features of the system. However, they expressed some difficulties:

1. Students cited the absence of the ability to save the displayed traces and therefore, its reuse.

2. A research feature of specific learners' traces is absent from the system.

3. Students mentioned the lack of tools for saving conversations made by their tutors.

6. Conclusion and Future Work

Tutoring activity has become an essential task in distance learning environments. Several researchers have focused their researches on an emerging track, which is the instrumentation of tutors' roles (Garrot, 2008; Rasoavelorina, 2012). In these researches, several appointments were given to the term of "tutor" without a consensus or standardization of his roles and functions. In this paper, we presented our contribution and vision about the instrumentation of online tutors' roles.

Our contributions focus on the proposal of a new approach to tutor modeling and a new tutors grouping technique. In fact, we contribute to the efforts made in the instrumentation of tutors' roles by proposing a new tutor model structure, which is based on his cognitive and tutoring profiles. The tutoring profile includes roles that we found essential for taking into account all the assistance requests submitted by learners.

Our second contribution concerns the proposal of a new tutors grouping method. Indeed, if a lot of research was doing on learners grouping for various reasons (collaboration, performance prediction, etc.); no work has been done on the grouping of tutors in e-learning systems. This led us to study the impact of grouping tutors into groups and propose new methods. As a result, we proposed a new technique called K-complementarity, which is based on the tutoring profile of tutors. The obtained groups are characterized by a complementarity coefficient, which measures the degree of complementarity between the members of each group.

To validate our ideas and proposed formulas, our contributions have been implemented by a system, which facilitates the collaboration among tutors. The developed system (i.e. Tut-Class) was tested at an Algerian University where good results were obtained. From these results, several improvements can be considered. Indeed, several lines of research are considered in short and medium term.

Firstly, we want to study the effects of collaboration among tutors on the performance of learners on one hand and on the tutors themselves on the other. This collaboration has double objectives. On one side, it can help tutors to respond to the assistance requests that are sent by learners, by collaborating with other tutors when the target tutor doesn't know how to solve requests individually or when the response is considered unsatisfactory by the learner requesting assistance. On the other side, this collaboration offers an adaptive space for the exchange of experiences between the tutors. So, collaboration activity can promote tutors' training and increase their levels.

Secondly, another research work that we want to start is the filtering of traces left by human actors during tutoring process. These traces must undergo several treatments before being filtered. Thirdly, another future work concerns the study of different techniques for initializing the profile of the tutor and the establishment of a standard that can be adopted by any e-learning platform adopting tutoring.

Finally, we aim to conduct another experiment of the developed system before its final use at any higher-education institution. This experiment, on a larger sample, can validate our choices and in particular, the proposed technique for grouping tutors and the usefulness of the complementarity coefficient.

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Contact address:
Yacine Lafifi
LabSTIC Laboratory
University 8 May 1945 Guelma
BP 401
Guelma, 24000
Algeria
e-mail: Laf_yac@yahoo.fr

Safia Bendjebar
LabSTIC Laboratory
University 8 May 1945 Guelma
BP 401
Guelma, 24000
Algeria
e-mail: bendjebar_s@hotmail.fr

Amina Zedadra
LabSTIC Laboratory
University 8 May 1945 Guelma
BP 401
Guelma, 24000
Algeria
e-mail: zedadra_a@yahoo.fr

YACINE LAFIFI is currently working as an Associate Professor at the Computer Science Department of Guelma University, Algeria. Also, he is a senior researcher at LabSTIC laboratory (Guelma University, Algeria). He works in e-learning research field since 1997. He received his Ph.D. in computer science from the University of Annaba (Algeria) in 2007. He has several published papers in conferences and journals. Furthermore, he is an editorial board member of many international journals. Currently, he works on educational data mining techniques, CSCL, recommender systems, MOOC and human tutoring systems.

SAFIA BENDJEBAR is currently a PhD student in computer science at LabSTIC Laboratory (Guelma University, Algeria). She has worked for three years on educational data mining techniques. She is preparing a PhD thesis about the modeling of tutors in e-learning systems. Her current research concerns e-learning systems, tutors modeling, classification, and data mining techniques.

AMINA ZEDADRA is currently a PhD student in computer science at the University of Guelma, Algeria. Also, she has been preparing her PhD thesis at the Laboratory of Research (LabSTIC) since 2012. Her PhD research is the use of learning traces to improve collaborative learning environments. Her current research interests include e-learning, bio-informatics and multi-agent systems.

Appendix 1

The proposed algorithm uses a function for calculating the complementarity of a vector T_i. The code of this function is the following.

Algorithm 2: Complementary function

Input: Vector T_i
D: set of unclassified tutors {tutors don't belong yet to a group}
Output: Vector T_s

Begin
Take a tutor j (represented by T_j) randomly from D
$D=D-\{T_j\}$
Coef=coef−resemblance (T_i, T_j) {calculate the degree of the resemblance between
the two vectors T_i and T_j}
$T_s = T_j$

For all T_p in D **do**
  If coef−resemblance (T_i, T_p) <Coef **then**
   Coef=coef−resemblance (T_i, T_p);
   $T_s = T_p$
  End If;
End For

End.

For calculating the degree of resemblance between two vectors T_i and T_j (i.e. **coef-resemblance(T_i, T_j)**), we use the following code:

```
S=0
For c=1 to size(Ti) do
    If Ti[c]=Tj[c] then
    S=S+1
    End If
End For
Coef-resemblance(Ti, Tj)=S
```

Appendix 2

The questionnaire used for initializing the tutoring profile of a tutor.

Tutors' roles	Can you perform the following tasks?	Response		
		Yes	No	Maybe
Pedagogue	Identify the learning difficulties			
	Establish the objectives of the learning objects			
	Solicit the exchange of the resources between the learners			
	Seek the establishment of relations between some parts of the course			
	Provide resources related to the contents of the studied subjects			
	Select a set of pedagogical resources that you must schedule and complete with your own production, in order to propose them to the learners			
Administrator	Answer the various administrative questions			
	Remind learners about the deadlines (calendar: dates of the enrollment, examination dates, etc.)			
	Answer general questions about the courses			
	Check whether the objectives of the courses are known and understood			
	Control the order and the flow of the discussions' subjects			
	Monitor the members who are apart from the discussions			
	Monitor closely the progress of the learners' activities			
Coach	Correct the errors of the learners			
	Establish a work plan			
	Guide the learners toward the best technological and pedagogical choices			
	Guide the learners in their research query, therefore to develop skills in the research field			
	Give feedback on the interventions of the learners			
	Facilitate the learning process for the learners			
Evaluator	Evaluate and certify the acquired knowledge and the skills developed by the learners			
	Evaluate the needs, the difficulties, the rhythm and the preferences of each learner			
	Solicit the self-assessment of the learners' activities			
	Create detailed learning objects during the progression of the course			
	Establish the objectives of the activities and work on the specification of each learner's course			
Supervisor	Technical guide: answer simple questions about technical problems (you must be familiar with the system)			
	Help the learners to present, communicate, participate and interact			
	Help the learner to choose his personal projects			
	Help the learner to reflect on his own tasks			
Facilitator	Clarify and advise the learners on the adequate choice of communication tools according to the type and the moments of the activity			
	Provide indicators to facilitate the access to the information			
	Clarify points of methodology			
	Help the group to specify common projects			

Organizer	Establish the agenda of the session			
	Pose rules and procedures for the activity of the learner			
	Suggest an agenda and a timetable for the activities			
	Answer the questions of the learners concerning the working method			
	Control the exchanges between the members of the group			
	Clarify the rules and procedures of the discussion			
	Create a pedagogical scenario that offers a high degree of freedom			
Moderator	Support the interactions between the learners, especially between those who have different qualification levels			
	Motivate the isolated learners to integrate in the group			
	Support the interactions among the learners			
	Explain the principles of the communication charter			
	Ask questions and encourage learners to discuss and criticize			
	Encourage the learners to be clear, and to finish the sessions			
	Discuss with the learners the evolution of their learning			
Psychologist	Raise the problems of motivation, conflicts, etc.			
	Simulate, restart and motivate the learners (especially after the failure in an exam, getting bad marks, etc.)			
	Listen to the learners to help each one of them to overcome the difficulties			