Support of group working: tools for the analysis of web-based collaborative working behaviours


ABSTRACT

Functional roles may be able to explain the learning performance of groups. However, it is not at all easy for teachers in either conventional classrooms or web learning systems to identify the functional roles played by students in a group and the relationship between roles and group performance. In a web learning system, interactions among group members can be recorded in a database. Tools can then be developed to assist teachers to recognise the roles played by group members and hence to know what is the best intervention strategy to support group learning. This study designed a methodology for automatically identifying the role played by students through an analysis of their web collaborative learning interactions. A regression prediction strategy is also proposed to predict group performance according to the identified functional roles. Teachers can therefore recognise the status of group members’ participation and suggest strategies to the students which might increase their learning performance.

Keywords: Group member roles analysis, web-based collaborative learning, monitor and intervene group learning, facilitate web-based group learning

INTRODUCTION

To explore how the behaviour of group members affects group performance, many social science researchers have focused on group role analyses. For example, Robbins (1991) indicated that a role is “a set of expected behaviour patterns attributed to someone occupying a given position in a social unit”. Moreover, Chesler and Fox (1966) indicated that a role is “a patterned sequence of feelings, words, and actions”. Most research in this area have emphasised the effect of group leadership on group performance (Keedy, 1999; Reponen, 1999). However, the existence of member-roles as an effective indicator for group performance has been rather neglected (Benee & Sheats, 1948). Some studies have investigated the affect of member-roles on group performance. For example, Belbins’ team-role theory (1981), Biddle’s role theory (1979), Benne and Sheats’ (1948) and Heap’s research (1977) all noted that member-role functionality affects group performance. Meanwhile, Henry and Stevens (1999), Sommerville and Dalziel (1998) provided experience related to exploring the effect of member-roles on team building and group work. These studies provide valuable experience for teachers wishing to use group roles to facilitate group monitoring.

However, detecting the existence of roles within a group is not easy. In a conventional classroom, teachers must monitor all group interactions closely. If a
class contains numerous groups, teachers are unable to monitor all groups. Teachers may be able to obtain indications of learning performance by questioning students directly or distributing questionnaires (Biddle, 1979). Regardless of the approach used, teachers need to expend considerable effort on monitoring group members’ functional roles.

Today, web-based group learning environments have been used widely to support students in learning. However, it is still difficult for teachers to identify students’ functional roles and collaborating performance. Teachers can check the intra-group dialogs over time to find the functional roles because group functional roles are developed based on social interactions and can become part of the social identity of individuals (Biddle, 1979). It is possible to record the contents of group interactions in a database and then explore the relationship between role and group learning performance. This allows teachers to use the findings to monitor and enhance the collaboration to improve learning outcomes.

However, in accomplishing these tasks, teachers always encounter certain problems. First, the social interactions of students are always extensive and unorganised, meaning teachers must spend considerable time and effort on identifying the roles played by students. Second, the relationship between member-roles and group learning performance must be captured to allow teachers to monitor group learning and make timely interventions.

Many researchers are currently trying to analyse logs to provide users with adaptive information. Gardner et al. (2002) proposed a web-based learning and assessment system to support flexible education. Liaw (2002) integrated several perspectives to understand user perceptions of World-wide web environments, including the Technical Acceptance Model, Social Cognitive Theory, individual attitudes, motivation and self-efficacy perspectives. Chen et al. (2003) used group communication to monitor web-based group learning. Those analyses can help teachers identify students’ collaborative learning status. Teachers can, therefore, remind students of their collaboration, but cannot understand their contribution in functions. Accordingly, teachers can advise students to take charge of role functions to increase collaborative learning performance.

This study designed a methodology for automatically identifying the functional roles that students play in their web-based group collaborative learning according to their collaborative learning behaviours which were recorded in web server. Machine learning and statistical tools were applied to analyse their functional roles and to identify the relation between the roles and learning performance. Teachers can, therefore, monitor students’ group collaborative learning status in view of functional role. Besides, teachers can also predict whether a group will give up before the end of the collaboration and can intervene in time to help avoid that outcome. Furthermore, identifying the key roles that will affect group learning performance can let teachers know what is wrong with the group collaboration so that they can intervene in students’ collaboration ‘just-in-time’.

METHODOLOGY OVERVIEW

To support teachers interventions in students’ collaborative learning, this research developed a web-based collaborative learning environment. All students’
web learning behaviours were recorded by the system to provide data which could be
analysed to determine their collaboration status. Machine learning technique and
statistic prediction methods were used to identify the functional roles played by group
members and also to forecast the group learning performance. In this approach,
teachers can discover students’ collaborative learning status in close to real-time, and
can also find out which of them discharge their responsibility or which functional role
does not work well. Teacher’s instant and informative feedback can help the group
collaboration process. The prediction of collaborative learning results allow students
and teachers know how to reach their learning and teaching goals.

However, it is not easy to determine what functional roles have been played by
group members. Therefore, the web-based system used in this research provided
several online functions in group collaborative learning environment to support
students in knowledge sharing and task management. When those functions were used,
students’ online behaviours were recorded to identify who had done what. In this way,
the system can create a measure of who has joined the collaboration and what
functions have been performed.

The collaborative learning system provides the following functions in the web
group collaborating space:

a. project entry and environmental development times.
b. new group mission times.
c. working diary times.
d. response/reply to working diary times.
e. enter group collaboration environment times.
f. online instant message use times.
g. access group resource times.
h. file upload times for resource sharing/collaborating.
i. browsing self-assessment times.
j. e-mail sending times.
k. e-mail reading times.
l. article reading times on discussion boards.
m. article posting times on discussion boards.

To extract social interaction patterns from group interactions on the web learning
system, this study employed information retrieval techniques to assist teachers in
analyzing a large quantity of textual group interaction in a database. The IBM
Intelligent Miner is a commercial product that extracts the topics and abstracts of
documents that assist teachers to identify the roles played by students in a group
according to role theory.
Figure 1 illustrates the process flow through which teachers can identify the member-roles and determine their effect on group learning performance. A 'role-identify' tool is built for capturing the functional role playing status in a group. Three learning performance indicators were considered to determine the effect of the roles on: individual grades, group project grades and drop out rate. Average individual grades were determined from individual examination outcomes. These outcomes indicate the learning performance of individuals and the assistance given to individuals by other members. Group project grades are determined from group project outcomes. These outcomes represent groups' learning performance and individual assistance to groups. The relationship between member-roles and both individual and group learning outcomes is explored below. Finally, a good group should also encourage all members to participate (Rabow et al., 1994). Many teachers in CMC learning environments are concerned with ensuring students do not give up and drop out. Thus, this study also explored the relationship between the existence of the roles and group drop out rate.

DETECTING ROLES IN A WEB GROUP LEARNING ENVIRONMENT

This section describes the member-role categories of Benne and Sheats (1948). All of the definitions of member-roles are employed in the web group learning environment. Teachers can identify a role by examining learning behaviours, member interaction patterns, and questionnaire answers by students. The IBM text miner is employed to extract the topic and keywords of each contribution that students made on their group discussion board to help determining the group role.

Functional roles of group members

Benne and Sheats (1948) identified 27 member-roles in their research ‘Functional roles of group members’, and classified these roles into three broad categories:

- Group task roles: participant roles in this group are related to group tasks, including initiator-contributor, information seeker, opinion
seeker, information giver, opinion giver, elaborator, coordinator, orienter, evaluator-critic, energiser, procedural technician and recorder.

- Group building and maintenance roles: participant roles in this group are related to alerting or maintaining group ways of working, including encourager, harmoniser, compromiser, gate-keeper and expediter, standard setter/ego ideal, group-observer/commentator and follower.

- Individual roles: participant roles in this group are not related to the group task or functioning, but instead are related to individual goals, including aggressor, blocker, recognition-seeker, self-confessor, playboy, dominator, help-seeker, special interest pleader and fellow-traveller.

This study employed the above classifications of member roles. The following section describes the criteria for detecting member-roles by observing the interactive patterns and individual learning behaviour corresponding to the above member-role definitions.

Criteria for detecting member-roles by observing the interactive patterns and individual learning behaviours

According to the three broad role categories, eleven member-roles were identified in an experimental class by observing the interactive patterns and individual learning behaviours. Researchers have defined the member-role criteria (Benne and Sheats, 1948; Chen et al., 2001), including the semantic definitions and learning behaviour logged in web-based learning systems. The criteria for these member-roles are listed below:

- **Initiator-contributors**: members who deliver the ‘solution’ and ‘new concept’ interactive patterns in group interaction to initiate a group task, and who have a login frequency exceeding four times a week.

- **Information givers**: members who deliver the ‘related information’ and ‘experience’ interactive patterns in group interaction to assist other members in solving problems related to group tasks, and who have a login frequency exceeding four times a week.

- **Opinion givers**: members who deliver the ‘argument-opinion’ interactive pattern during group interactions and oppose, agree with or revise the positions of others, and who have a login frequency exceeding four times a week.

- **Coordinators**: members who deliver the ‘inquiry-opinion’ interactive pattern during group interactions and coordinate the position of group members position on group tasks, and who have a login frequency exceeding seven times a week, with a frequency of working on tasks exceeding three times a week.

- **Energiser**: members who deliver the ‘proposing the conference’ interactive pattern in group interaction, who increase group coherency when working on tasks, and who have a login frequency exceeding four times a week.

- **Procedural technicians and recorders**: members who deliver the ‘schedule’, ‘task tracking’ and ‘task assigning’ interactive patterns when working on group tasks, and who have a login frequency exceeding seven times a week with a frequency of working on tasks exceeding twice a week.

- **Encouragers**: members who deliver the ‘admire’ and ‘concern’ interactive patterns to encourage members to learn, and who have a login frequency exceeding four times a week.

- **Followers**: members who do not deliver any ‘opinion’ interactive pattern, but have offered the
‘agree’ interactive patterns of the ‘arguments-opinion’ interactive pattern and who have a login frequency exceeding four times a week and interaction delivering frequency is less than twice every week.

- **Playboys**: members who deliver the ‘gossip’ interactive patterns, and whose login frequency exceeds four times a week and whose frequency of delivering interaction is less than twice every three weeks.

- **Dominator**: members who deliver the ‘decision making’ interactive patterns, and whose login frequency is more than seven times a week.

- **Fellow-travellers**: members who do not deliver any interactions, and whose login frequency is once a week or none.

In this study, the learning system tries to detect the above 11 member-roles by investigating group interactive patterns, login frequency and frequency of project related work. Based on the above criteria, each student plays certain member-roles in a group. Notably, a student may play several roles simultaneously, and conversely, a group may also contain several members who are concurrently playing the same roles.

**Role detecting method**

Functional role determination is used to analyse and predict whether a student has played a specific functional role. Two methods are proposed to assist teachers identify functional roles played by group members bearing in mind that each student might play more than one functional role at the same time.

One method uses a text summarisation tool that can help the teacher to check students’ collaboration dialog for determining functional roles. The other is to analyse students’ group collaborating portfolio automatically to determine whether a student has or has not played some functional role or roles.

The IBM text miner was used to extract the topic and keywords of each contribution made by students on their group discussion board to help determine their group role. This approach allows teachers to track group discussions simply by reading the discussion topics and summaries rather than reading through the actual contributions to the discussion board.

For example, the following extract from the discussion is a contribution by group member Michael Chen:

> Dear teammates:

> Sorry for being late for our on-line conference this morning.

> After viewing the current status of our group project, I think we should work faster.

> Some other groups have already finished identifying project goal and allocating specific tasks among different members.

> First, I think we should determine the project topic.

> How about designing a web-based word memory system?

> Such a system can test the ability of learners and can train them to learn in a step-by–step fashion.

> Does anyone have any comments or suggestions related to this topic?

Michael Chen
The text miner extracted: *First, I think we should determine the project topic to summarise Michael Chen’s discussion.*

The key sentence from the contribution facilitates teachers in identifying the learning status of the group. Based on the results of the text mining, teachers can see the student acting as an Initiator-contributor.

The text summary function uses a ‘word ranking’ and ‘sentence ranking’ method to identify which sentence is relevant. In the word ranking method, the (text frequency) * (inverse document frequency), or (tf*idf) technique (Salton & Buckley, 1988) was used to identify the important words in the document. Another criterion used for word ranking is whether the word occurs in the title, a heading or a caption. In the sentence ranking method, the sentence score is the sum of the following:

- Scores of individual words in the sentence multiplied by a coefficient set in the configuration file.
- Proximity of the sentence to the beginning of the paragraph multiplied by a coefficient set in the configuration file.
- Final sentences in long paragraphs and final paragraphs in long documents receive a higher score.
- Proximity of a paragraph to the beginning of the document multiplied by a coefficient set in the configuration file.

The second method uses a machine learning technique to predict student’s functional role playing status based on group learning portfolios. A machine learning tool, the *Neural Classification in IBM Intelligent Miner*, was used to identify the roles played by students in their group. In other words, we use characteristics of students’ web-based collaborative learning behaviours to forecast whether the student had played specific functional roles.

The study used two courses to examine role predicting effectiveness. One of the courses was used as training data to generate role-prediction rules, while the other course was used as testing data for rule evaluation. Table 1 shows the input data for the IBM Intelligent Miner for Classification. The first column is the student ID and the following 11 columns represent whether a student was regarded as having specific functional roles. Whether a student had played specific roles were determined by questionnaires from group members’ opinion. In the questionnaire, we defined questions based on Benne and Sheats’ (1948) functional role definition to let students express their feeling whether their group members had played specific functional roles. One of the questions in the questionnaire was ‘Who has provided related information to assist in group development?’ a question that was used to gain the opinions of students regarding other group members who were information-givers. The rest are the accumulations of student’s system using times and web collaborative functions using times. After the table had been input into the classification software, the software generated an experience rule for prediction the next time according to collaboration portfolios.

**Table 1. Training data for functional role prediction when using IBM intelligent miner**

245
Table 2. Functional role prediction results by the IBM intelligent miner

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Are you a Initiator-contributor</th>
<th>Are you a Information givers</th>
<th>Are you a Opinion giver</th>
<th>Are you a Coordinators</th>
<th>Are you a Energizer</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>89860021</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>...</td>
</tr>
<tr>
<td>89860022</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>...</td>
</tr>
<tr>
<td>89860031</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>...</td>
</tr>
<tr>
<td>89860005</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>...</td>
</tr>
</tbody>
</table>

Table 2 shows the classification results produced by the IBM classification tool. The table was generated by using group collaboration portfolios of Class B to determine what kind of functional roles each Class B student had played. For example, student ‘89860021’ was classified as someone who was not an Initiator-contributor but rather an Opinion giver.

To verify the functional role forecasting accuracy, the experiment involved two online courses which took place simultaneously with similar learning environments. One course, *Introduction to Computer Networks*, (Class A) had 40 students, while the other, *Database Systems*, (Class B) had 42 students. The students included elementary and middle school teachers from all over Taiwan, none of whom had majored in computer science. The experiment took place over two months in 2001. Students in Class A were split into six groups, and students in Class B into seven groups. Every student needed to collaborate with their group members on web-based learning system.

Additionally, the study has established thresholds for each functional role to increase the accuracy. The determination of thresholds was according to Chen et al.’s (2001) experimental results. For example, an individual can be considered as an Initiator-contributor only if they have a login frequency exceeding 4 times a week.

Table 3. Accuracy of functional role forecasting results

<table>
<thead>
<tr>
<th>Group role</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiator-contributors</td>
<td>92.5%</td>
</tr>
<tr>
<td>Information givers</td>
<td>95%</td>
</tr>
<tr>
<td>Opinion givers</td>
<td>97.5%</td>
</tr>
<tr>
<td>Coordinators</td>
<td>95%</td>
</tr>
</tbody>
</table>
Table 3 shows the accuracy of predicting students’ functional role playing status according to their web learning behaviour. The table shows not every functional role can be predicted successfully based on our strategy, only considering students’ login times and every collaborative function using times. For example, the method is insufficient in determining whether a student was a ‘Procedural technician and recorder’ or a ‘Follower’. It seems need to check their dialog to improve the drawback. In spite of this, the predicting results compared with students’ opinions in average have a 90% accuracy rate. The analysis results can let teacher know whether students have participated and what kind of functional roles had been played by each student.

### LEARNING PERFORMANCE PREDICTED BY FUNCTIONAL ROLE ANALYSES

To help teachers to realize students’ collaborative learning performance and to know how to intervene in students’ collaboration, two analysis methods were proposed to reveal the relation between learning performance and functional role playing status.

To analyse the relationship between member-roles and indicators of group performance, namely average individual grades, group project grades, and drop out rate, a statistical $t$-test was used to examine the significant range of periodicity (with $p$-value, $p<0.01$) on these three indicators. Meanwhile, linear regression analysis was applied to explore the relationships between the existence of member-roles and group performance. This information can assist teachers in understanding the affect of member-roles on learning performance. Furthermore, teachers can ask somebody to take charge of some functional role to increase collaborative efficiency.

The experiment included seven teachers, five teaching assistants and 706 students. The students included elementary and middle school teachers from all over Taiwan, none of whom had majored in computer science. The students included in the experiment were studying a course on 'Introduction to Computer Networks' in a web-based group learning environment. The students and teachers communicated via a computer network. The course lasted two months, from January to March in 2000. The class adopted a group learning strategy with a web interface for performing and recording group projects and inter and intra group discussions. The curriculum included fundamental concepts relating to computer networks and programming language/application for constructing WWW pages, including TCP/IP, Network security, HTML, JavaScript and FrontPage. Teachers captured the group interactions based on the web logs. To support group collaboration, each group was allowed to elect the leader, co-leader and recorder at the end of the first week.
Evaluation of the relationship between the existence of member-roles and group learning performance

To evaluate whether member-roles affect group learning performance, $t$-tests were used first to examine whether member roles have a significantly different influence on the three indicators of learning performance, namely, individual grades, group project grade and drop out rate. The statistical results are listed below:

Table 4. Significance of the influence of detected member-roles on individual grades, group project grades, and group drop rate.

<table>
<thead>
<tr>
<th>Detected Member-roles</th>
<th>Individual grades</th>
<th>Group project grade</th>
<th>Drop out rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiator - contributor</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Information - giver</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Opinion - giver</td>
<td>0.000*</td>
<td>0.185</td>
<td>0.063</td>
</tr>
<tr>
<td>Coordinator</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Energizer</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Procedural technician</td>
<td>0.000*</td>
<td>0.011</td>
<td>0.000*</td>
</tr>
<tr>
<td>Encourager</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Harmonizer</td>
<td>0.000*</td>
<td>0.018</td>
<td>0.046</td>
</tr>
<tr>
<td>Playboy</td>
<td>0.000*</td>
<td>0.008*</td>
<td>0.008*</td>
</tr>
<tr>
<td>Dominator</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>Fellow-traveller</td>
<td>0.122</td>
<td>0.003*</td>
<td>0.003*</td>
</tr>
</tbody>
</table>

*p < 0.01

Table 4 shows the effects of functional role in group collaborative learning and students’ learning results. If the value is less then 0.01, it means someone who had played the functional role will have significant difference in learning results. The values marked with ‘*’ mean it is less then 0.01. Second column of Table 3 reveals that a student who plays a role performs significantly better in individual grades, except for the fellow-traveller role. Regarding group project grades (third column of Table 3), the detected member roles played by students in a group significantly affect group project grades, with the exceptions of the opinion-giver, procedural technician and harmoniser. Additionally, the drop out rates are also affected significantly by the functional roles of members, except opinion-giver and harmoniser. According to the results and functional role detecting tools, teachers can instruct group members to take charge of some functional responsibilities to promote different collaborative learning outcomes.

Roles played by each pre-defined roles (leader, vice-leader, recorder) that affect group project grade

Linear regression analysis (using SPSS 8.0) was applied to investigate whether the functional roles (R1, R2..., R11) significantly influenced group project grades.

Sixteen groups gave up halfway through the course, and thus received a group project grade of zero. The remaining 54 groups received project grades ranging from 67 to 92. Therefore the distribution of project grades concentrates heavily on zero.
This phenomenon obviously is inappropriate for the usual linear regression model. The analysis first undertook a logistic regression analysis to predict the probability of failure for each group. The analysis demonstrates that the logistical regression analysis can successfully predict failure groups, and the significant roles are R1 (Initiator-contributor), R2 (Information-giver) and R4 (Coordinator). Second, linear regression analysis was applied to cases with grades greater than zero.

Following are five analyses to determine what kind of group member whose functional roles playing status will affect group collaboration effectively, including all group members, leader, co-leader, recorder, and three group executives.

Analysis of functional roles of all group members:

This work first studied the relationship between group performance and the functional roles played by group members. The role playing status of all group members were considered to be the independent variables in the linear regression model. Table 4 lists the estimated regression coefficients and the corresponding significance levels. The table indicates that most of the variables did not significantly affect group grades, with the exception of R10 (Dominator). The model created by Table 5 has an R-square value of 0.617. As mentioned earlier, some of the variables may have similar functions. Consequently, a stepwise regression analysis was applied to ensure good variable selection, and the results are listed in Table 6 with R²=0.558.

Table 5. Coefficients related to each functional role played by all group members that affect group project grades.

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>73.390</td>
<td>8.590</td>
<td>8.544</td>
<td>.000</td>
</tr>
<tr>
<td>R1</td>
<td>-1.278</td>
<td>1.192</td>
<td>-.136</td>
<td>-1.072</td>
</tr>
<tr>
<td>R2</td>
<td>1.178</td>
<td>.857</td>
<td>.172</td>
<td>1.375</td>
</tr>
<tr>
<td>R3</td>
<td>.967</td>
<td>1.078</td>
<td>.217</td>
<td>.897</td>
</tr>
<tr>
<td>R4</td>
<td>.151</td>
<td>1.496</td>
<td>.013</td>
<td>.101</td>
</tr>
<tr>
<td>R5</td>
<td>2.012</td>
<td>1.283</td>
<td>.207</td>
<td>1.568</td>
</tr>
<tr>
<td>R6</td>
<td>-.655</td>
<td>1.372</td>
<td>-.061</td>
<td>-.478</td>
</tr>
<tr>
<td>R7</td>
<td>1.157</td>
<td>.764</td>
<td>.210</td>
<td>1.514</td>
</tr>
<tr>
<td>R8</td>
<td>-.102</td>
<td>.854</td>
<td>-.019</td>
<td>-.119</td>
</tr>
<tr>
<td>R9</td>
<td>.113</td>
<td>.972</td>
<td>.023</td>
<td>.116</td>
</tr>
<tr>
<td>R10</td>
<td>3.159</td>
<td>1.220</td>
<td>.340</td>
<td>2.589</td>
</tr>
<tr>
<td>R11</td>
<td>-.313</td>
<td>1.122</td>
<td>-.053</td>
<td>-.279</td>
</tr>
</tbody>
</table>

Table 6. Coefficients related to each functional role played by all members that affect group project grades.

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
</table>
This next regression model only reserved predictors R7(Encourager), R5(Energiser) and R10 (Dominator) in relation to group project grades. Although using three independent variables reduces R-square value from 0.617 to 0.558, it yields a more reasonable significance test and significantly simplified the model, and thus the resulting R-square is acceptable. The following concentrates entirely on stepwise analysis.

Analysis of functional roles of group leader:

This study then examined the relationship between group performance and the functional roles played by group leaders. The following are the results obtained from stepwise linear regression analysis.

Table 7. Coefficients related to the functional role played by the leader of each group that affect group project grades.

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>81.976</td>
<td>.994</td>
<td>82.441</td>
<td>.000</td>
</tr>
<tr>
<td>R10</td>
<td>7.022</td>
<td>1.162</td>
<td>.675</td>
<td>.000</td>
</tr>
<tr>
<td>R9</td>
<td>-6.143</td>
<td>2.162</td>
<td>-.307</td>
<td>-2.841</td>
</tr>
<tr>
<td>R4</td>
<td>-3.871</td>
<td>1.279</td>
<td>-.359</td>
<td>-3.027</td>
</tr>
<tr>
<td>R5</td>
<td>2.688</td>
<td>1.030</td>
<td>.277</td>
<td>2.609</td>
</tr>
</tbody>
</table>

This present model contains R square value 0.457. The use of this value indicates that the functional roles R4(Coordinator), R9(Playboy) and R10(Dominator) played by the group leader are significantly related to group collaborative outcomes. Table 7 provides reasonable support to the claim that the leader must play the ‘dominator’ role during group collaboration. On the other hand, if the leader does not dominate a group or is a playboy, this will harm group collaboration.

Analysis of functional roles of co-leader and of recorder:

The linear regression analyses were not successful in examining the relation between group performance and functional roles of the co-leader. Moreover, the linear
regression analyses also failed to reveal any data on the relation between group performance and functional roles played by the recorder, possibly due to collinearity of the independent variables.

Analysis of functional roles of three group executives:

Finally, the study examined the relationship between group performance and the functional roles played by the leader, co-leader and recorder. This study increases the number of objects of analysis from one student to three students (group executives) to determine whether their group role playing status will be more closely related to group collaborative outcome. Again, the stepwise method gives the results listed in Table 8. The factor reserved as the predictor is only R10 (Dominator). Accordingly, it can be concluded that all dominative behaviours involve group executives. The R square value here is just 0.298, which indicates that considering three group executives is not a reliable means of predicting group performance with a linear regression model.

<table>
<thead>
<tr>
<th>Coefficients related to the functional roles played by three group executives that affect group project grades.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
</tr>
<tr>
<td><strong>R10</strong></td>
</tr>
</tbody>
</table>

**DISCUSSION**

The experimental results show that considering the functional role playing condition of all group members is a more reliable method of predicting group learning performance. This study only considers whether group performance prediction ability decays with the representation of leader or group executives in functional role playing. However, the importance of group leaders depends on whether they fulfil their responsibilities, a result that is similar to some previous research results (Henry & Stevens, 1999; Keedy, 1999; Reponen, 1999). Moreover, in this work the functional role playing status of the co-leaders and recorders appears to have no particular effect on group collaboration. These two executive members can be considered to be general members. Restated, designating the two executive members is not necessary, and it must be ensured that the leader dominates the group and other members participate constructively.

The two methods ‘stepwise’ and ‘all’ in linear regression analysis have different benefits. While the ‘stepwise’ method reduces the number of predictors, it also reduces the R-square value. ‘All’ methods of linear regression analysis uses all factors in the regression model. The drawback of linear regression analysis is that it must consider all factor values when predicting final group project grades. However, from the analysis, using the stepwise analysis method appears a good means of creating
awareness of the group collaborating performance of students.

CONCLUSION

To help teachers monitor and intervene Web-based group collaborative learning, this study presented a methodology for identifying the functional-roles played by each student automatically. Students’ web group collaboration portfolios were recorded and analysed to determine functional roles and learning performance. The machine learning tool, IBM Intelligent Miner for Data, has been successfully employed for identifying member-roles. This methodology can help teachers to recognize easily the types of roles played by group members in a web-based group collaborating environment. Three primary group performance indicators were considered to assess group collaboration results, namely: (1) individual grade, (2) group project grade, and (3) drop out rate. The relation between those indicators and functional role playing status was analyzed as information for teacher to facilitate group collaborative learning.

In addition, functional-role playing statuses were used to predict group collaborative performance through prediction strategy of statistics. Regression analysis demonstrates that group executives (leader, co-leader, recorder) must do their duty in the group, or else the group will suffer from a high probability of collapse, resulting in poor learning outcome. Restated, if a teachers wish to achieve successful group collaboration, they should pay attention to the three pre-defined roles. Considering the roles played by all group members, the roles Encourager, Energiser and Dominator positively affect group project grade, while the roles fellow-traveller and playboy have a strong negative affect on group project grade. Therefore, the role identification mechanism and learning performance predicting strategy can make teachers aware of group collaboration status in time, like assigning somebody charged with some role to enable learning. That means given the assistance of member-roles in detecting and influencing extraction tools, teachers can monitor group learning by examining the existence of group member roles and thus gain an improved idea of how to assist students in collaboration.

ACKNOWLEDGEMENTS

The authors would like to thank the National Science Council, Taiwan, ROC, (Contract No. NSC93-2524-S-008-002) and the MOE Program for Promoting Academic Excellent of Universities under the grant number 91-H-FA08-1-4 for financially supporting this research. Jun-Ren Hwang and Hong-Wen Xiao are also acknowledged for constructing the online collaboration system and applying the IBM data mining tool for data analysis.
References


IBM Intelligent Miner for data and text: developed by IBM Company, URL is http://www-3.ibm.com/software/data/iminer/


Reponen, T. (1999) Is leaderships possible at loosely coupled organization such as university? Higher Education Policy, 12, pp.237-244.


SPSS 8.0: developed by SPSS Inc. http://www.spss.com/


