

## iGLS: Intelligent Grouping for Online Collaborative Learning

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### Abstract

*One of the factors that affect successful collaborative learning is the composition of collaborative groups. Due to the lack of intelligent grouping according to learners' pedagogic needs in current online collaborative learning environments, developing intelligent grouping according to individual learners' cognitive characteristics is highly desired. In this paper, we propose a new approach to supporting intelligent grouping based on learners' learning styles. Our approach achieves the balance of different levels of learning styles in group composition. We demonstrate how it can fit into current activity-based collaborative learning environments and how it could be applied in a real world application.*

### 1. Introduction

Online collaborative learning extends learning beyond the classroom and creates relationships between learners which construct their learning through collaborative learning environments and at their own learning speed [1]. Management research suggests that collaboration makes people work together more effectively [2]. However, the issue of forming collaborative groups has to be considered for online collaborative learning as group construction affects its performance. In order to address this issue, the factors that improve the creation of well-functioning learning groups are explored. Recently, an increasing number of researchers have identified *learning styles* as one of the important learner characteristics and found that they can be used to successfully improve adaptive collaborative activities [3, 4]. We thus apply learning styles to the grouping process for online collaborative learning.

In this paper, we propose iGLS (Intelligent Grouping based on Learning Styles) as an approach to developing intelligent grouping for online collaborative learning. iGLS achieves keeping the balance of different levels of learning styles for collaboration and is adaptable with components fitting into current activity-

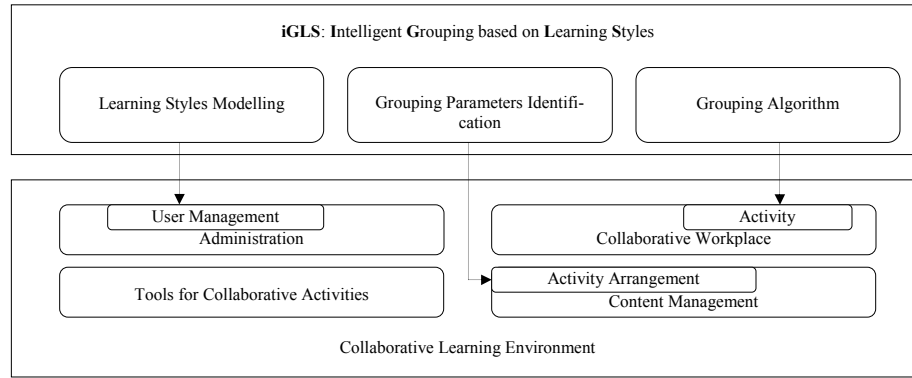
based collaborative learning environments. Our experiments using iGLS for grouping on LAMS [5] demonstrate the feasibility of applying iGLS to real scenarios of online collaborative learning.

### 2. Effect of Combined Learning Styles on Group Collaboration

A learning style is an individual's preferences about taking in and processing information. People with different learning styles can generate different perspectives on an effective interactive strategy [6]. Consequently, learning styles are expected to affect the development of collaborative work. Alfonseca *et al.*'s [7] case study indicates that groups with mixed learning styles in the active/reflective and sensing/intuitive dimensions of the Felder-Silverman model work better than groups with similar learning styles. Sandmire and Boyce [8] found that learning pairs with opposite learning styles performed significantly better on a simulated clinical case than learning pairs with specialized learning styles.

### 3. iGLS: Intelligent Grouping based on Learning Styles

A collaborative learning environment provides an online learning community with an interactive and multi-functional working area. The functions that a collaborative learning environment can provide are diverse, and can vary from educational administration to content management. The major functions that current environments (e.g. Moodle [9], LAMS [5], WebCL [10] and Blackboard [11]) provide are illustrated in Figure 1. The function of administration allows technicians to maintain the collaborative learning system and course managers to manage online courses. The collaborative workplace allows online learners to carry out learning activities together and interact with each other remotely in synchronous or asynchronous ways. The tools for collaborative activities support learners in performing learning related activities from



**Figure 1. iGLS and collaborative learning environment**

the learning process to the assessment process. In a collaborative learning environment, content management allows learning resources to be categorized and presented and collaborative activities to be defined and arranged for a particular course. Each function of the collaborative learning environment can comprise several sub-modules as follows:

- Administration:
  - user management
  - course management
  - system settings
- Collaborative workplace:
  - activity performing
- Tools for collaborative activities:
  - tools for learning activities such as chat, forums, bulletin-boards, etc.
  - tools for assessment activities such as questions, submit files, multiple choices, etc.
- Content management:
  - learning resources management
  - collaborative activity arrangement

iGLS is proposed to support intelligent grouping of learners for online collaborative learning, which incorporates learners' cognitive aspects – learning styles for forming heterogeneous groups (i.e. learners with different levels of learning style). The process of iGLS includes extracting learners' learning styles through collaborative learning environments, and adopting these learning styles and the grouping parameters (e.g. the number of learners per group) to assign learners to different collaborative groups. Thus, the proposed iGLS contains the three components shown in Figure 1:

- Learning styles modelling
- Grouping parameters identification
- Grouping algorithm

*Learning styles modelling* is the process of acquiring learning style scores from individual learners. Since the Felder-Silverman model [12] has been successfully applied for describing learning styles for

adaptive learning [3, 13, 14], Felder and Soloman's Index of Learning Styles (ILS) questionnaire [15] has been adopted in iGLS to extract learners' learning styles through the collaborative learning environment. Learning styles are applied later in the grouping algorithm for the grouping process.

*Grouping parameters identification* is the process to determine the values of parameters to use in the grouping algorithm. In iGLS, the grouping parameters refer to the number of learners per group and the number of groups to create. These parameters are determined by a course manager when a particular collaborative activity is arranged. Since Wessner and Pfister [16] suggest that three to five learners is an appropriate size for group activity, the value of the parameter 'number of learners per group' ranges between three and five learners in iGLS. Either of the two grouping parameters can be selected to use for grouping. In this paper, the grouping algorithm adopts the number of learners per group as the parameter for the grouping process.

The *grouping algorithm* is the method for ordering, segmenting and assigning learners into heterogeneous groups according to the learning style scores obtained and the grouping parameters defined. Our grouping algorithm improves that presented in a previous study [17]. The description of the grouping algorithm is given below and the pseudo-code of the algorithm is provided in Algorithm 1.

Let  $L$  be the set of total learners to be grouped,  $N$  be the number of learners per group, and  $R$  be the remainder when the total number of learners is divided by the number of learners per group ( $L$ ,  $N$ ,  $R$  are integers).

**Initializing:** randomly select  $R$  learners from  $L$ ; create  $M$  empty groups but when  $R$  equals to  $N-1$  create  $(M+1)$  empty groups. Here  $M = \frac{Size(L)-R}{N}$ .

**Ordering:** sort the set of  $(Size(L) - R)$  learners from highest learning style scores to lowest learning style scores.

**Segmenting:** divide the ordered learners into  $n$  segments. Here  $n$  equals to  $N$ .

**Algorithm 1:** The pseudo-code of iGLS grouping algorithm

```

1. Initializing
2. remove (R, L);
3. if (R = (N-1)) createGroups(M);
4. else createGroups(M+1);

5. Ordering
6. sorted = sort(L-set(R));

7. Segmenting
8. int index = 0;
9. for i = 0 to n
10.   for j = 0 to M
11.     segArray [i] [j] = sorted.get(index);

12. Assigning
13. for i = 0 to M
14.   rNum = randomGenerator();
15.   for j = 0 to n
16.     for k = 0 to M
17.       segList.add(segArray[j][k]);
18.       gArray[i][j] = segList.get(rNum);
19.   addLearnersToSelectGroup(gArray, learnersInActivity);

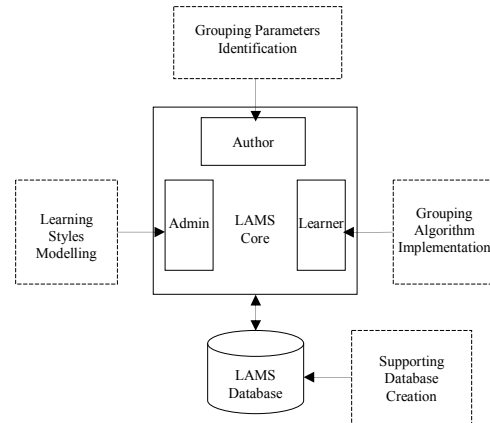
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**Assigning:** randomly select one learner from each segment and assign them to one of the  $M$  empty groups. For each of the following remainder cases, assign the remaining learners accordingly: assign each of the remaining learners to one of the  $M$  groups; when  $R$  equals to  $(N-1)$ , assign all the remaining learners to the  $(M+1)$  group.

The three components of iGLS are designed to fit into current collaborative learning environments (as shown in Figure 1). The *learning styles modelling* component is built on the *user management* module in the *administration* function of the underlying collaborative learning environment. While online learners establish their personal profiles in the collaborative learning environment, they can also take part in the Index of Learning Styles questionnaire to produce the learning style scores for iGLS. The *grouping parameters identification* component is completed in the *activity arrangement* module in the *content management* function of the collaborative learning environment. A course manager can determine the values of the grouping parameters while they apply grouping for an online collaborative learning activity for a particular online course. The *grouping algorithm* component is incorporated into the *activity* module in the *collaborative workplace*. When individual learners start a collaborative activity in the collaborative workplace, they are automatically divided into different groups according to the proposed grouping algorithm.

## 4. iGLS Implementation for LAMS

iGLS can be implemented as an add-on for current collaborative learning environments. In this paper, we



**Figure 2. iGLS implementation for LAMS**

take LAMS [5] as an example environment for illustrating the detailed implementation of iGLS.

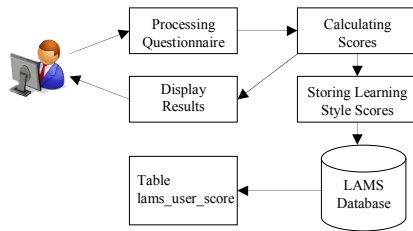
### 4.1 The Reasons for Choosing LAMS

Learning Activity Management System (LAMS) [5] is used for designing, managing and delivering online collaborative learning activities. It is open source, and so is becoming widely adopted by universities and other educational institutions [5]. The availability of source code and detailed on-line help and examples assist developers and researchers in adopting LAMS.

### 4.2 Phases of Implementation

The iGLS implementation for LAMS has four phases: learning style modelling, grouping parameter identification, grouping algorithm implementation and supporting database creation (Figure 2). We use LAMS 2.1, which is based on the J2EE platform and has a modular architecture consisting of core services and tools for collaborative activities. The LAMS core manages the arrangements of activities ('Author'), allocates learners to groups, manages learners' progress in particular activities ('Learner'), etc. The core is also in charge of logins, system administration ('Admin'), etc. LAMS tools are self-contained modules, forming most of the functionality that the 'Learner' interacts with.

The four phases of the iGLS implementation for LAMS are built up on different parts of LAMS (Figure 2). 'Learning styles modelling' is incorporated in LAMS 'Admin'. The 'grouping parameters identification' adopts the original function that LAMS 'Author' provides for defining the parameters for its own grouping component. The grouping component of LAMS includes two approaches for grouping online learners: *chosen grouping* in which a course manager assigns



**Figure 3. Implementation of learning styles modeling**

learners manually, and *random grouping* in which learners are divided into groups by the system automatically. However, neither of these approaches supports grouping learners according to their cognitive aspects i.e. learning styles as iGLS proposes. The ‘grouping algorithm implementation’ is integrated in LAMS ‘Learner’. The ‘supporting database creation’ is a phase which sets up the database tables for the implementation. The phases are as follows.

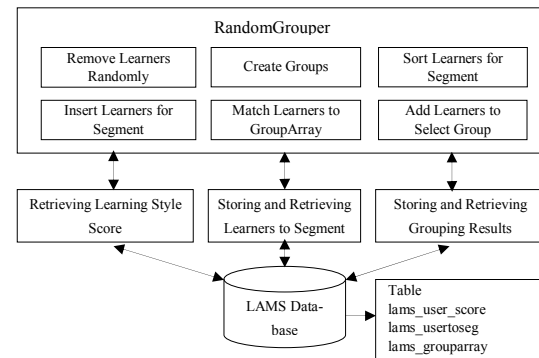
**Learning Styles Modelling:** Since groups organized according to learning styles in the active-reflective dimension work better [7], the learning style score on the active-reflective dimension is used to represent the learners’ learning style in this implementation. Learners’ answers to the Index of Learning Styles Questionnaire are processed by the module for calculating scores (Figure 3). Calculated scores are displayed for learners and stored in the LAMS database.

**Grouping Parameters Identification:** A course manager determines the grouping parameter values when they create a lesson (a sequence of collaborative learning activities) through LAMS ‘Author’. We adopt the LAMS 2 function to define grouping parameters.

**Grouping Algorithm Implementation:** Object-oriented programming is applied for implementing the iGLS grouping algorithm. The random grouper module performs the grouping process, consisting of several sub-modules according to the steps addressed in Algorithm 1 such as creating groups and sorting learners for segmenting (Figure 4). The middle layer of the figure shows the modules for processing learning style scores and the grouping results with the LAMS database.

**Supporting Database Creation:** Three tables are used. Table ‘lams\_user\_score’ stores the extracted learning style scores after learning styles modelling, ‘lams\_usertoseg’ stores the learners for segmenting after randomly removing remaining learners from the total set of learners for a grouping activity, and ‘lams\_grouparray’ stores the grouping results when the grouping process is completed.

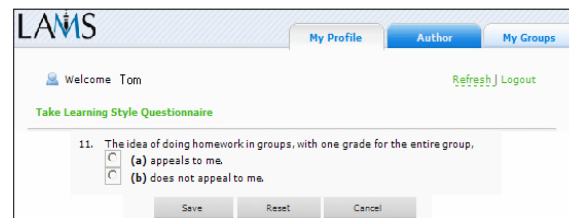
### 4.3 Case Study



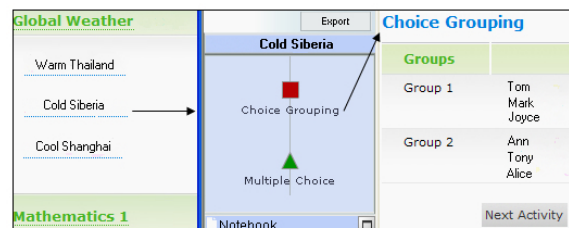
**Figure 4. iGLS group algorithm implementation**

In order to demonstrate how the iGLS implementation for LAMS works, a case study of the implemented tool is presented. The scenario for this case study is a geography course named ‘Global Weather’ created in LAMS with six registered learners. The course manager creates a lesson named ‘Cold Siberia’ containing a sequence of two simple online collaborative learning activities: a grouping activity and a multiple-choice activity. The grouping activity uses the iGLS grouping algorithm for forming collaborative groups, which will affect the following multiple-choice activity. The number of learners per group was defined to be three by the course manager through LAMS ‘Author’. An individual learner is expected to take the learning style questionnaire before starting a lesson (Figure 5). Learners’ learning style scores are applied to the choice grouping activity after all learners finish the questionnaire. The six learners are put into two mixed groups (Groups 1 and 2), as shown in Figure 6 for ‘Cold Siberia’.

The case study shows us that iGLS for grouping on



**Figure 5. Screenshot of “take learning style questionnaire”**



**Figure 6. Screenshot of “grouping result for the lesson of ‘Cold Siberia’”**

LAMS works well and it is practical to apply iGLS to real world applications.

## 5. Related Work

Forming effective groups is a critical issue for improving the quality of collaboration for online collaborative learning. Current collaborative learning environments that provide grouping functions for online group activity do not consider individual learners' cognitive characteristics. Consequently, they provide manual or automatic grouping which does not incorporate the pedagogical needs for collaboration.

Several collaborative learning environments support chosen grouping, such as [5, 9, 11]. The problem with chosen grouping is that the efficiency of the grouping process may become very low when constrained by (for example) large class size and time limitation.

Compared with chosen grouping methods, random grouping methods provide intelligent grouping which increases the efficiency of the group formation process in collaborative learning environments, such as [5, 9]. Although random grouping can increase the likelihood of heterogeneous groupings, it still does not guarantee that grouping is done according to individual learners' preferences for collaboration.

## 6. Conclusion and Future Work

In this paper, we present our novel grouping methodology, iGLS, based on learners' learning styles. Through implementing iGLS on top of LAMS, we believe iGLS can easily fit into real online collaborative learning environments.

In the future we aim to test our approach with real learners to gain feedback about the effectiveness of learning styles on group collaboration. Furthermore, as the ILS questionnaire may not be fully reliable and learners' learning styles may change, we plan to develop a method to detect learners' learning styles from their behaviors when interacting with collaborative learning environments and modify the original learning styles used for the grouping process.

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