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Using students' learning style to create effective learning groups in MCSCL environments

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***Abstract*—Students have different ways for learning and processing information. Some students prefer learning through seeing while others prefer learning through listening; some students prefer doing activities while other prefer reflecting. Some students reason logically, while others reason intuitively, etc. Identifying the learning style of each student, and providing learning content based on these styles represents a good method to enhance the learning quality. However, there are no efforts on how to detect the students' learning styles in mobile computer supported collaborative learning (MCSCL) environments. We present in this paper new ways for automatically detecting the learning styles of students in MCSCL environments based on the learning style model of Felder-Silverman. The identified learning styles of students could be then stored and used at anytime to assign each one of them to his/her appropriate learning group.**

Keywords—component; learning styles; mobile learning; collaborative learning; MCSCL, group formation.

I. INTRODUCTION

Collaborative learning is defined by Dillenbourg as "a situation, in which two or more people learn or attempt to learn something together" [1]. Collaborative learning represents an effective way to develop some students' personal and social skills that could not be strengthened by the individual learning (e.g., "making ideas explicit, communicating with others, reasoning, arguing and negotiating") [2].

With the development of new information and communications technologies (ICT), the distance and face-to-face collaborative learning is becoming much more easy, useful and rapid than before. And with the arrival of the mobile and wireless technologies (Smartphones, Tablets, PDAs, etc), the learners are becoming able to learn and interact with each other freely and naturally, and they could do their collaborative works in reel world environments (museums, gardens, forests, etc) using those new technologies. As result, a new approach of collaborative learning termed "Mobile Computer Supported Collaborative Learning" (MCSCL) is immerged, and many educational MCSCL projects were implemented [3], [4], [5].

On the other hand, the effective formation of learning groups is considered as one of the important keys for succeeding the collaborative learning activities [6]. Many grouping criteria are proposed by the researchers for forming mobile learning groups. For instance, the age [7], [8]; the gender [8]; the learners' interests [9], [10]; the learners' interactions [9], [11]; the learners' locations [12], [13], etc. In one of our previous work [14], we proposed a group formation approach that takes into consideration the biggest possible number of grouping criteria, and gives instructors the possibility for selecting the ones that they find more useful according to the types of learning activities, the learners' needs, the objectives, etc.

Among the group formation criteria that are not properly studied and considered in MCSCL environments is the learning style of mobile learners. Felder and Silverman find that students have different learning styles, they have "different strengths and preferences in the ways they take in and process information" [15]. Therefore, we focus in this paper on how to automatically detect the different learning styles of mobile learners, and how to re-group them according to the detected information, which can help enhancing the learning quality by forming the most suitable learning groups.

Two methods are generally followed by researchers to detect the students' learning styles; questionnaire-based method, and automatic method. The first method allows instructors (or learners) to have a quick but not always true ideas about the learning style of students. Because it is based on the use of questionnaires that are filled out by the students, and in many cases, the students do not provide sure information. In the contrary, the second method permits to obtain dynamic and sure information about the students' learning styles. Because it continuously controls and evaluates the students' behaviours (e.g., preferences). In this study, we use the second method for automatic detection of mobile students' learning styles. The different information related to the students' learning styles is stored in a specific database, which is accessed by the group formation algorithm that serves to form homogeneous or heterogeneous learning groups according to instructor's choices or the students' needs.

The paper is organized as follows: section 2 shows a description of the Felder and Silverman learning style model, and how to detect the learning styles using questionnaires. In

section 3, the proposed approach for automatic detection of learning styles, together with the system architecture are presented; finally our conclusions together with the further works are provided.

II. FELDER AND SILVERMAN'S LEARNING STYLE MODEL

In literature, many models of learning styles are proposed. Between them we find these of Honey and Mumford [16], David Kolb [17], Neil Fleming [18], and Felder and Silverman [19]. In this work, we are focusing on the last one, which is the most known model.

In 1988, Felder and Silverman proposed their first learning style model that aims to classify students according to the ways in which they prefer to learn or to obtain information [20]. According to this model, which is revised by Felder in 2002, four dimensions of learning style are considered (active/reflective, sensing/intuitive, visual/verbal, and sequential/global) (see Figure 1). We present in the following subsections brief description of the four dimensions of Felder and Silverman's learning style model.

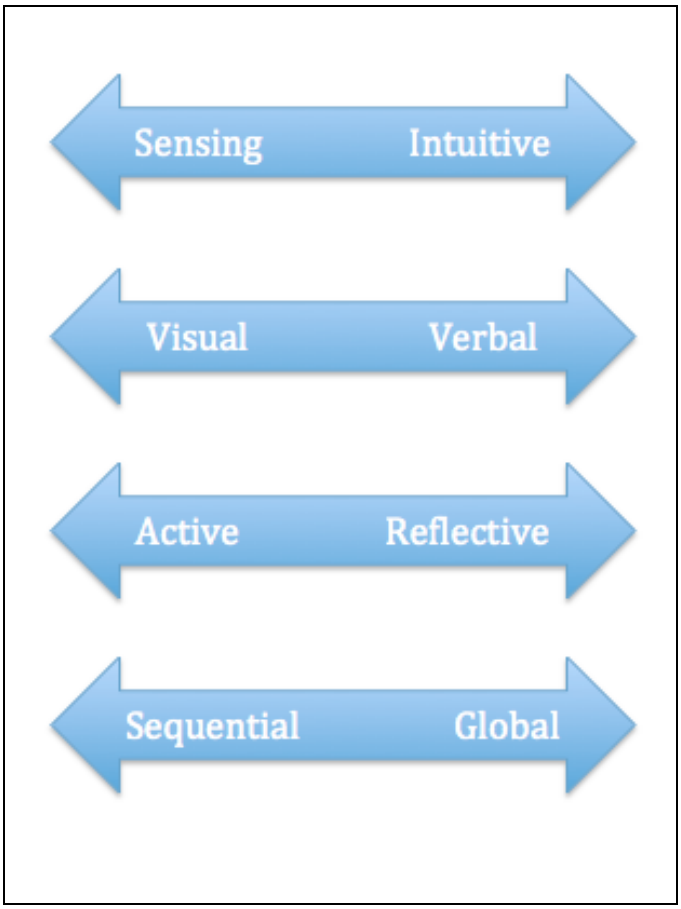

Figure 1. The four dimensions of Felder and Silverman's learning style model.

1. *Sensing or Intuitive:*

Sensing learners prefer concrete learning content (materials) such as data and facts. They enjoy materials that are related to real world, and they like solving problems using established methods.

Intuitive learners prefer to learn innovation and abstract content, such as theories, ideas and underlying meanings.

2. *Visual or Verbal*

Visual learners remember generally what they see, and they prefer visual representations of the presented learning content (e.g., figures, cards, diagrams, flow charts).

Verbal learners (or auditory learners) prefer spoken and written explanations. They learn better through listening to teachers, to mates, to their own voices, etc.

3. *Active or Reflective*

Active learners are characterized by their capacities for processing information actively. They prefer discussing, exchanging ideas, explaining information to others, and trying things out. They like more working in groups, and finding ways to use or apply information.

Reflective leaners prefer to think about the learning content (or materials) first. They prefer working passively and alone, and they benefit from thinking of possible questions related to what has been read.

4. *Sequential or Global*

Sequential learners learn in small incremental steps using a linear thinking process.

Global learners learn in large jumps. They try to see the big picture first and then the details.

In literature, two methods are followed by the educators to detect and identify the learning style of students: collaborative (questionnaires-based), and automatic methods [21]. As for the collaborative one, Felder and Soloman proposed the most known index for learning style (ILS) [22]. It is composed by 44 questions that cover the four dimensions of Felder and Silverman learning style model. For instance, to detect if a learner is visual or verbal, she/he should answer these questions:

- I remember best: (a) What I see. (b) What I hear.

- When I think about what I did yesterday, I am most likely to get: (a) a picture. (b) Words.

- I prefer to get new information in: (a) pictures, diagrams, graphs, or maps. (b) Written directions or verbal information.

- When someone is showing me data, I prefer: (a) charts or graphs. (b) Text summarizing the results.

- When I see a diagram or sketch in class, I am most likely to remember: (a) the picture. (b) What the instructor said about it.

The answers of such kind of questions allow instructors to have an idea about his/her students' preferences, and therefore, provide adaptive learning to each one of them. However, the

obtained students' answers are not always correct, which can affect the validity and the accuracy of the obtained results.

For the methods based on the automatic detection of students' learning style, the majority of existing approaches in this context are designed for online learning environments (E-learning platforms) [21], [23], [24]. And we have found only one paper for mobile learning and MCSCL environments [25].

III. PROPOSED MECHANISM FOR DETECTING THE SUDENTS' LEARNING STYLES

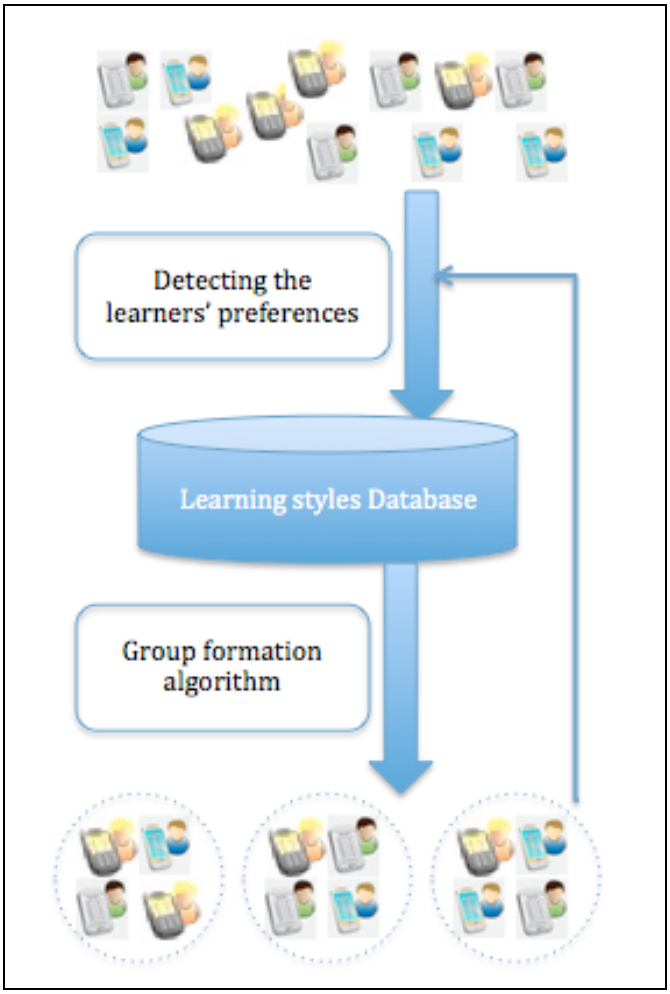

Figure 2. The proposed mechanism for grouping students based on their learning styles

AS shown in Figure 2, the proposed mechanism is composed by the following phases:

1. students' behaviours detection :

The objective of this step is to detect the students' learning behaviours, by extracting relevant information from mobile devices. Our challenge in this context is how to control, evaluate, and store the different students' behaviours (interactions, communications, movements, etc). As solution, we have proposed to install a set of log files on the device of each student. Those files serve to store, in real time, the different actions and activities of students, together with the necessary details (e.g., learning time, visited places, visited forums). At the end of learning activities, the system extracts the necessary information from the log files and stores them in an active database. To identify the learning style of each student, a specific module, termed *learning style identification*, analyzes the students' profile and identifies their styles according to the obtained information (see the subsection entitled "Learning styles identification").

In the following subsections, we present the necessary information that we can extract from the mobile devices to define the learning style according to the four dimensions of Felder and Silverman model.

- Sensing / Intuitive: while sensing students enjoy concrete materials (e.g., data, statistics), and intuitive students prefer abstract content (e.g., theories, ideas), we propose to analyze the history of accessed learning content (visited forums, websites, applications, etc). In addition, intuitive students like challenges and hard missions. This kind of information can be obtained from the history of chosen activities.

- Visual / Verbal: a given mobile student can be considered as visual student if she/he often accesses to image-sharing websites (such as Google image or google map), or she/he takes photos of every discovered thing, or draws graphs to understand or explain his/her ideas. While verbal students like communication with their teachers and mates. Therefore analyzing the level of interaction with others helps identifying the visual/verbal dimension of each student. In addition verbal students prefer visiting video-sharing websites (such as YouTube) and recording interesting information using audio and videos recorders.

- Active / Reflective: To detect if a given student is active or reflective, we propose to analyze the history of his/her activities. The active learners enjoy working collaboratively in groups, they like explaining and presenting their ideas to others, and they enjoy interacting directly with learning objects (flowers, animals, robots, etc). While reflective students prefer working alone and reflecting about the learning materials without doing many experiences.

- Sequential / Global: To detect if a given student is sequential or global; we propose to analyze also the history of her/his activities. The sequential students like the details of every learned material, therefore, they ask many questions about those materials, and visit (access) many times the same place, learning object, website, video, picture, etc. While the global students tend to obtain a general idea about the learned materials, therefore, they ignore many steps, contents, and details.

2. Learning styles identification:

After evaluating and storing the different values related to the students' learning behaviours (which are associated to the four dimensions of Felder and Silverman's learning style model), the system searches to define the preferred learning styles of each student.

To achieve this objective, we have followed the method proposed by Graf et al [26]. This method is based on the use of

indications from the behaviours of students. For instance, if a student uses often his/her smartphone to take photos of learning objects, this gives a hint that this student prefers visual learning style.

For each student's behaviour, there are four values of hints: 3 indicates that the student's behaviour represents a strong positive indication for the learning style. 2 indicates that the student's behaviour does not represent a specific hint (it is an average value). 1 indicates that the student's behaviour represents a strong negative indication for the learning style. 0 indicates that there is no information to identify the learning style.

In order to obtain a measure for a given learning style, the system calculates the sum of all the hints and divide them on the number of considered behaviours.

3. Learning groups formation:

After detecting and storing the students' learning behaviours and identifying their learning styles, the instructors could at anytime ask the group formation algorithm to form the learning groups. In order to make the formation of groups more global and useful for different situations, we have considered both types of learning groups; homogenous and heterogeneous groups. To form the first type of groups, the principles of K-means clustering is used. As for creating heterogeneous learning groups, the grouping algorithm calculates the Euclidian distance between all existing two learners (the similarity matrix) and starts to form the initial groups by selecting the learners that have the highest values in the similarity matrix. When all groups are composed by two learners, the grouping algorithm calculates then, the new distances between each created group and the rest of students that are not yet assigned to any group. Then, the algorithm finds the highest value and assign the selected learner to the selected group. The grouping algorithm repeats this process until finishing the affectation of all learners.

As for the architecture of the proposed system, we have used a client/ server architecture, which is composed by three tiers (see Figure 3):

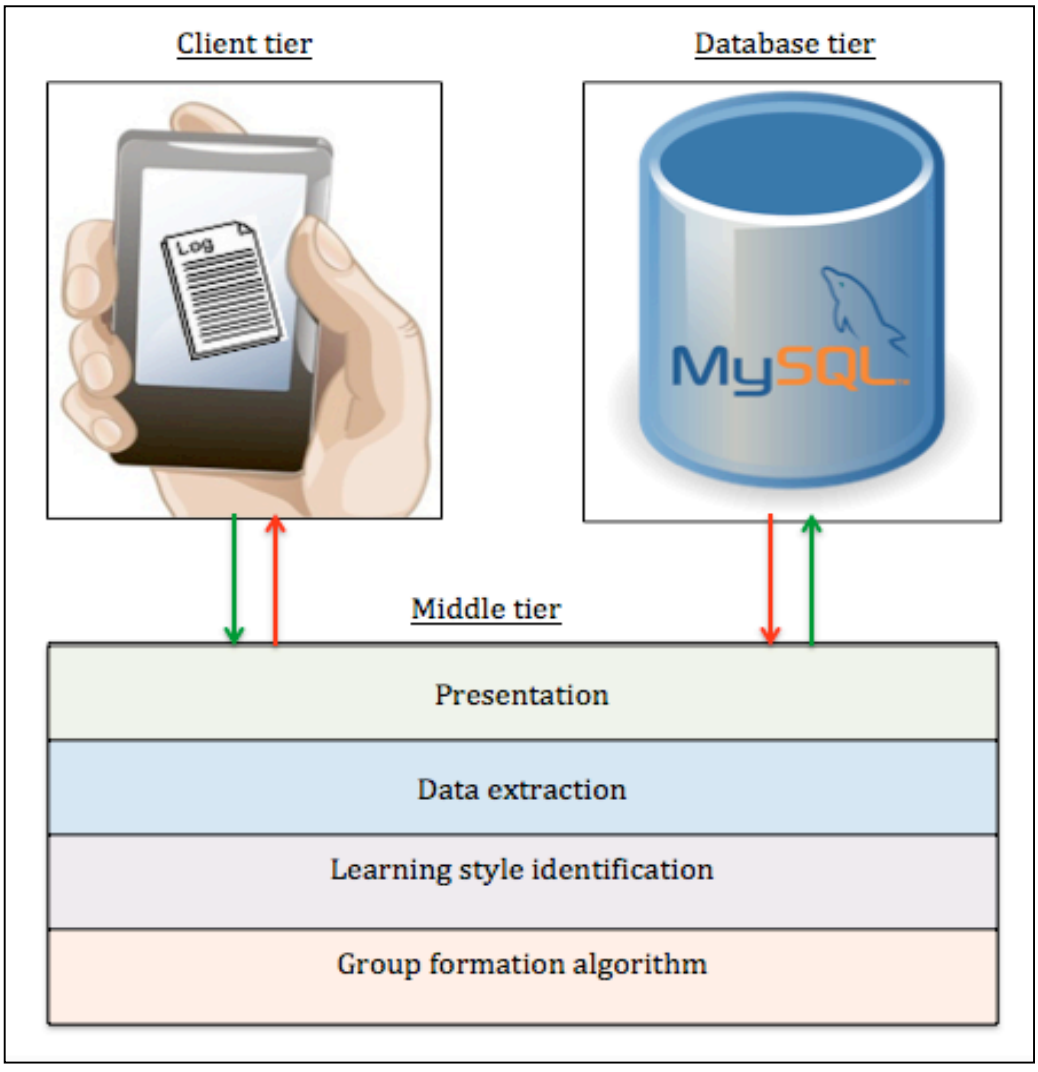

Figure 3. System architecture

- Client tier: in which mobile devices allow students to interact with the system through their Internet browsers. This tier permits also to store instantaneous information of student's behaviours in a set of log files.

- Database tier: represents the active database of the system, and serves to store the necessary information of students and their past activities.

- Middle tier: represents the main part of the system. It communicates with the database tier through JDBC protocol. The middle tier is composed by four modules: *Presentation module*, allows students and teachers to access to learning resources, and to use the group formation algorithm, through servlets and JSP pages. *Data extraction* module, helps the system to extract the relevant information from the log files installed on the mobile devices. *Learning style identification module*, analyses the students' profiles and their past activities to identify their learning styles. *Group formation* algorithm, forms the best possible learning groups during the collaborative learning activities according to the identified learning style of each student.

IV. CONCLUSION

Learning styles vary for each one of students. This paper proposed an automatic method to detect the learning styles of mobile students, and to form suitable homogeneous or heterogeneous groups according to the detected information. We have assumed during this study that the MCSCL environments are completely different from the non-mobile environments (e.g., CSCL: Computer Supported Collaborative Learning). Through our literature review, we have found only one paper that focuses on the problem of students' learning style detection in MCSCL environments [25]. Therefore, we believe that the work presented in this paper was providing the MCSCL community with valuable information and ideas about this research problem.

As a further work, we would like to evaluate the proposed approach by comparing its effectiveness with those of the traditional way that uses questionnaires to identify the learning styles of each learner. This assessment method is based on the evaluation of the experimental learning groups' results (groups composed based on the learning styles identified with the proposed method) and compare them with the learning results of the control groups (groups composed based on the learning styles identified using the questionnaire method).

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