# USING LEARNING STYLES FOR DYNAMIC GROUP FORMATION IN ADAPTIVE COLLABORATIVE HYPERMEDIA SYSTEMS

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Collaborative tools have been used in educational contexts for supporting communication and collaboration among students, discussions about topics, cooperative problem resolution, knowledge sharing and collaborative knowledge construction. A proper use of these tools reduces student isolation in web-based courses and facilitates the development of personal and social skills. At the same time, it is generally assented that learning styles are the preferences of students regarding to how they learn. It is desirable that a web-based instructional system includes information about the student learning style to optimally adapt the whole course to the individual characteristics of the students. Due to the benefits of the use of learning styles in adaptive hypermedia systems and the benefits of collaboration, we propose the use of learning styles to automatically adapt collaborative activities in web-based systems. Learning styles can be taken into account by proposing or discouraging collaborative activities, grouping students and choosing the most suitable statement of the problem and collaborative tools for each group of students.

## 1 Motivation

Collaborative learning is a social activity that involves students and teachers of a community. It has been applied since the 70s in traditional courses, whereas the incorporation of computers to collaborative learning began toward the end of the 80s [18]. Later, thanks to the development of communications and technologies derived from group work, new applications arose in an area of study that has been termed *Computer-Supported Collaborative Learning* (CSCL).

Collaborative tools have been used in educational contexts to develop certain personal skills (thinking, reasoning, communication, knowledge construction) [2] [4] and social skills (group work, public speaking) [12] [14]. Therefore, collaborative systems can be of benefit to a student's learning process. Furthermore, in web-based education, it is very important to make sure that the information was designed in agreement with the needs of each learner (features, interests, goals, behaviour). The student has to feel comfortable with an environment that favours the communication, the exchange of ideas and

visualization of the work performed by their classmates. Consequently, a need to adapt collaborative issues to some of the features and behaviour of student in web-based systems is apparent [5].

The group's productivity is determined by how well the members work together. Sometimes, homogeneous groups are better at achieving specific aims; however, when we combined students with different abilities, experiences and interests (heterogeneous groups), they outperformed homogeneous groups in a broader range of tasks. If we allow the students to organize themselves, they usually form homogeneous groups, and if teachers are responsible for making the groups, they can select whether the groups will be homogeneous or heterogeneous [11].

In the 80s, some experts in psycho-pedagogy began to place emphasis upon working with individuals' learning styles, and it is within this sub-category of design considerations that we find many notable examples. Among them the work of Myers-Briggs (Myers-Briggs Type Indicator)[3], Kolb (Kolb's Learning Style Model)[13], Herrmann (Herrmann Brain Dominance Instrument)[10], and Felder-Silverman (Felder-Silverman Learning Style Model)[8].

In recognition of the fact that individuals learn in different ways, a body of research and technique has been developed that attempts to categorize individual variations while satisfying different learning style preferences. Learning style theory and practice is related to personality style and attempts to place individuals within a grid that is itself a matrix of categories such as introvert/extrovert, active/passive, splitters/lumpers, thinking/doing, and other variables.

While its critics may claim that such classification systems oversimplify human variation, or even suggest that such variation should be overlooked in favour of one teaching technique (typically didactic), the general trend in education is towards recognition of different learning styles and developing methods for reaching more students through their personal styles.

Only a few systems that attempt to adapt web-based courses to learning style have been developed, partly because it still is unclear which aspects of learning style are worth modelling, and what can be done differently for users with different learning styles [6] [9].

We have established a relationship between Felder learning styles and the web-based education features that could be adapted[17]. Sequential/global dimensions affect the "perspective" of the student, the point from where the student is looking at the course. Sequential learners prefer a narrow viewpoint while global learners prefer a broad viewpoint. Presenting the course in the preferred way may solve the problem of being lost in hyperspace for sequential learners and the problem of lack of freedom for global learners. The sensing/intuitive feature is related to the content, or rather the kind of content presented. Sensing learners prefer presentation of explanations after exemplifications and vice versa for intuitive learners. Visual/verbal is a

difficult dimension to adapt in web-based education because while in sequential/global and sensing/intuitive the system adapt the course sequence, in visual/verbal the adaptation could cause the elimination of some material. Even if you could express the same content in both ways, through words and through images, we do not find any reason not to present both formats in the same concept explanation or exemplification. Maybe the inclusion or not of images could depend on a great degree of technical requirements. We have found a practical use of this dimension in the presentation of collaborative activities, in a visual or in a verbal workspace.

In previous papers [15] [16], we proposed the adaptation of the contents and structure of the courses taking into account Felder's classification[7]. An experiment on sequential/global adaptation based on Felder-Soloman was further tested[1], showing that students benefit from learning material being adapted to suit their learning preferences. The active/reflective dimension is clearly related to *Computer Supported Collaborative Learning* (CSCL) and groupware applications that are being explored nowadays.

The work presented in this paper tries to combine collaborative learning with learning styles in order to use them as a main feature to select students in group formation. Due to the benefits of the use of learning styles in adaptive hypermedia systems and the benefits of collaboration, we propose to apply learning styles for collaborative aspects in adaptive web-based systems. Our main goal is to adapt the whole web-based course (individual and collaborative issues) to the needs of each student. For doing it, we use a new version of the TANGOW (*Task-based Adaptive learNer Guidance On the Web*) system that allows us to include and adapt collaborative activities in web-based courses[5]. Learning styles are taken into account by: i) proposing or discouraging collaborative activities for students, ii) grouping dynamically students and iii) choosing the most suitable collaborative activity (statement of the problem and collaborative tools) for each group of students that can accomplish the activity.

## 2 A formal model of group formation

To design a collaborative adaptive course in TANGOW[5], a teacher must specify the activities that compose the course (individual and collaborative), whether there are pre-requisites of certain activities or not, the navigational guidance offered, the multimedia contents used for dynamic page generation including the statement of the problem of the collaborative activities, the collaborative tools to support the communication between students for performing this type of activities and the criteria to dynamically group students.

The adaptation possibilities depend on one or more characteristics of the student (personal features, preferences, behaviour during the execution of the course) and should be specified during the course description. All these aspects constitute the user model. The teacher of the course can specify

any characteristic to take into account in the adaptation process with either discrete values or a range of values. For instance, a teacher could consider, among others, the learning style of the students, their previous knowledge and their behaviour during the accomplishment of exercises (individual and collaborative).

In order to detect the students learning style, we use the ILS (Index of Learning Styles) questionnaire. It was developed by Felder and Soloman based on the Felder-Silverman classification[7]. The ILS questionnaire's objective is to establish the dominant learning style of each student. ILS questionnaire is formed by 44 questions with two possible answers, a or b. These questions are separated into four groups, with eleven questions each. These groups correspond to four of the five categories in the classification of Felder and Silverman. Authors do not take into account the inductive-deductive dimension for pedagogical reasons. We use learning styles during the design phase to specify the presence or absence of collaborative activities for certain types of students, to group students automatically and to describe the collaborative workspaces (statement of the problem and collaborative tools) for each group of students and for each certain activity.

When teachers decide to insert a collaborative activity in a certain point of the course structure, they have to specify the type of students whom the collaborative activity applies to. A criteria to decide the presence or absence of collaborative activities could be the active/reflective dimension of the students' learning style (see figure 1 phase 1). Perhaps a collaborative activity might not be suitable for extreme reflective students (9 or 11 in the ILS questionnaire) because it is possible that this kind of students do not take part in the accomplishment of collaborative activities and they could damage to the rest of the members of the same group with their passive attitude. This is the default criteria, but the teacher of the course always can change it in the design phase.

It is necessary to describe the structure and the organization of the whole workspace for each collaborative activity. A collaborative workspace is constituted by the statement of the problem and a set of collaborative tools to support the communication between students. These collaborative tools are classified in main tools (which form the main interface of collaborative workspace) and the additional tools. The teacher of a course might specify the parts (statement and tools) of the collaborative workspace, their combination and organization, and the type of the students whom a specific collaborative workspace will be generated.

In order to adapt the collaborative workspaces to each group of students, one aspect to take into consideration is the visual-verbal dimension of ILS questionnaire. For moderate and strong visual students (5 to 11 in ILS questionnaire) it will be desirable adapt the collaborative workspaces (problem statement and / or collaborative tools). Regarding to well-balanced students, who have scored from 1 to 3, is not necessary to adapt the collaborative task

because they do not have learning style preferences. If the teachers of the course follows this criterion (using visual-verbal dimension of ILS questionnaire), they can decide to adapt only the collaborative tools to support the communication between students, the statement of the problem or both of them. If the teachers choose to adapt: i) only the collaborative tools, they might specify simply the concrete tools for visual students and for verbal students; ii) the statement of the problem, they might provide different version for the different types of students to the system and iii) the whole workspace, they have to specify different statements of the problem and the collaborative tools that constitute the collaborative workspaces.

Finally, the course teacher might specify the criteria for grouping students in collaborative activities. On the one hand, groups of students with different abilities, experiences and interests can outperform heterogeneous groups[11]. On the other hand, many students are reflective due to many reasons. Some of them can be that they do not like participating in traditional classrooms (face-to-face) because the teacher focuses his attention on them; they have not communication capabilities and so on. It seems clear that the active/ reflexive dimension of learning styles must be considered by dynamic group formation in collaborative activities in the new version of TANGOW system[5]. The default criteria in group formation could be to combine active students with reflective students in similar percentages. In this way, the students can benefit from their integration in heterogeneous groups. This criterion also can be change by the teacher in the design phase.

Once the course components have been described, the course itself is dynamically generated for each student by selecting, at every step, the most appropriate course components (activities to perform, problems to be solved, contents, collaborative tools, partners for each student, etc) based on the information stored in the user model such as the students' learning style. This information is updated in each step of the course.

When students are ready to accomplish a collaborative activity and the teacher of the course does not change the default criteria to propose collaborative activities to all students (excluding the extreme reflexive students), the system classifies them according to this criteria in order to present or not the collaborative activity (see figure 1, phase 1).

Once the system selects the students that are to perform a collaborative activity and the students are ready, they will be automatically grouped taking into account the visual/verbal dimension of the ILS questionnaire (see figure 1, phase 2). In this phase of group formation, students who have moderate and strong preference in either visual or verbal dimensions are grouped with similarly rated students to adapt the most suitable collaborative workspace according with their learning style. The well-balance students are grouped depending on the number of students doing the collaborative activity because they do not need a collaborative workspace adapted to them.

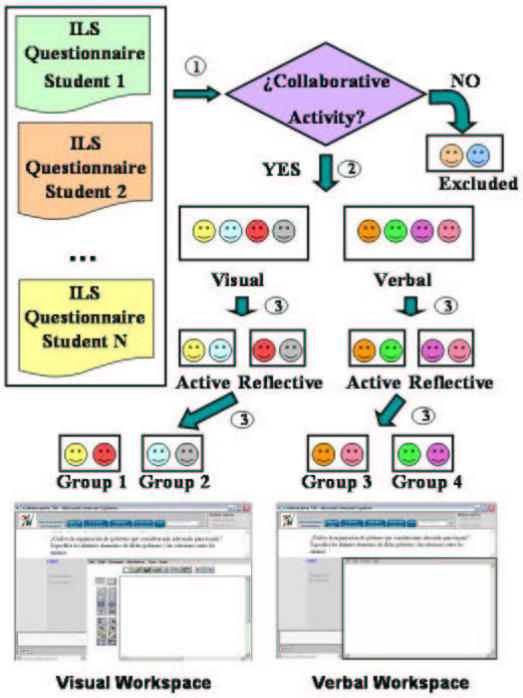


Figure 1. Use of learning styles in collaborative activities

Furthermore, by default, the system will build heterogeneous groups with around 50% of active students and 50% of reflective students (see figure 1, phase 3). The group average regarding to the active/reflective dimension should be as close as possible to zero. For example, if the teacher of the course decided that the groups of a certain collaborative activity have been constituted by three people, and there is a student with a score of 11 (positive score is associated to an active style while negative is associated to reflective), and another student has a score of -1, our system will try to find yet another student with -9 or -11.

The collaborative workspaces are dynamically generated when there are enough students to accomplish the collaborative activity (see figure 1, phase 3). In figure 1, different collaborative workspaces for visual and verbal students for the same collaborative activity are presented. As it is presented above, teachers could decide to adapt only the collaborative tools that support the communication and the performing of collaborative activity. Collaborative workspaces presented in figure 1 adapt the collaborative tools to support the communication among the students. A graphical editor is offered to the

group with at least a member with moderate or strong visual learning style, whereas a textual editor is offered to students with a member with moderate or strong textual learning style.

## 3 Conclusions and Future Work

Nowadays we have some conclusions: we could reduce the time that students spent in adaptive web-based courses taking into account learning styles. We propose that two of the four Felder dimensions (sensing/intuitive and sequential/global) could help students in their individual learning while the other two dimensions could help students in their collaborative learning. Our approach is, on one hand, to try to use the visual/verbal dimension to adapt the workspace to the learning style of the group, and on the other hand, to try to use active/reflective dimension to blend students in group formation. Furthermore, active/reflexive dimension is used to decide the presence or absence of collaborative activities.

There are still several open questions: how should we implement our system in the case of well-balanced students? Do learning styles change when students come into contact with students with different learning styles? What's happening if the system proposes collaborative activities to extreme reflexive students? Are these collaborative activities suitable for every student or only for some of them? Would it be of benefit to mix visual and textual students?

This approach needs to be tested with real students in order to get feedback about the effectiveness of using learning styles for dynamic group formation in adaptive collaborative web-based courses and also about the criteria to be used to adapt collaboration aspects such as the student grouping or the solutions of undesired situations. For doing these experiments, we are designing collaborative activities that allow the use of learning styles in existing courses. We have to create new adaptive collaborative courses and design the corresponding experiments. These experiments could also provide valuable information on the working and learning behavior, especially if we include semantic information to support the internal analysis of the student interactions, which we are considering. Furthermore, we also plan to develop a monitoring tool for the teachers to get information about the course evolution regarding to the use of learning styles in collaborative activities.

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