

Learning Group Formation Based on Learner Profile and Context

MARTIN MUEHLENBROCK

German Research Center for Artificial Intelligence DFKI, Germany
martin.muehlenbrock@web.de

An important but often neglected aspect in Computer-Supported Collaborative Learning (CSCL) is the formation of learning groups. Until recently, most support for group formation was based on learner profile information. In addition, the perspective of ubiquitous computing and ambient intelligence allows for a wider perspective on group formation, broadening the range of addressed features to include learner context information.

An important but often neglected aspect in Computer-Supported Collaborative Learning (CSCL) is the formation of learning groups. Most CSCL systems focus on mediating and supporting collaborative learning while the activity is going on, or after the activity has ended, by proving system functionality ranging from mirroring to guiding (Jermann, Soller, & Muehlenbrock, 2001). However, if support could also be given prior to the actual collaborative learning activity by suggesting appropriate group arrangements, many problems might be solved even before they arise and beneficial group processes might be boosted.

Until recently, most support for group formation was based on learner profile information such as gender, class, and so forth, including more sophisticated approaches based on the complementarity or overlapping of knowledge and competencies. This will be described in the following section. In addition, the perspective of ubiquitous computing and ambient intelligence allows for a wider perspective on group formation, broadening the range of addressed features to include learner context information such as location, time, and availability. This new perspective will be addressed in the third section.

GROUP FORMATION BASED ON LEARNER PROFILE

A general conceptual and formal framework for student model integration has been introduced in Hoppe (1995) under the notion of multiple student modelling, and has been extended in Muehlenbrock, Tewissen, and Hoppe (1998) for open distributed learning environments. The general premise is that individually assessed learner models can be used to support the configuration or parameterization of collaborative learning settings. These are prototypical cases:

- Given a number of students working on comparable problems in an open learning network, find pairs of students that could potentially benefit from cooperation in a joint session. The selection can be based on such criteria as complementarity or competitiveness.
- Given a group of students, select or generate a problem that forms an adequate challenge for the group as a whole. The problem should not be solvable by one student's knowledge alone, but rather through the union of all the students' individual knowledge bases. In this case, the challenge for the group consists in knowledge exchange and integration.

Selection criteria for these prototypical cases can be formulated on the basis of general modelling primitives such as *knows(Student, Topic)* or *has_difficulty(Student, Topic)*, which can be inferred from different standard types of student models. A simple case of knowledge integration is exemplified by the rule

$$\text{can_help}(\text{Student1}, \text{Student2}, \text{Topic}) _ \\ \text{knows}(\text{Student1}, \text{Topic}) \ \& \ \text{has_difficulty}(\text{Student2}, \text{Topic}).$$

Interestingly, there is a wide range of different support functions that can be implemented based on such a rule and further extensions:

- *Intelligently mediated peer help*: The individually assessed learner models are used to match pairs of learners that should maximally benefit from each other when working together. The prediction can be based on different criteria such as complementary skills/knowledge or competition.
- *Intelligently mediated expert tutoring*: Formally, this case can be considered as a specialization and simplification of matching peer learners, since only one of the models (the learner's) has to be dynamically assessed, whereas the tutors' profiles may be predefined.
- *Teacher/tutor support for supervising individual exercises*: Essentially a decision support function for the teacher. To achieve this it is sufficient to aggregate the individual learner models in a form that allows for filtering out specific features, for example, frequent problems. The support mechanism can also actively inform the teacher if adequate.

- *Group formation around given problems:* This is a generalization of mediating peer help in that the number of group members is not restricted to two. Also the problem requirements must be analytically specified.
- *Selection of adequate problems for a given group:* A problem is for example, selected or generated in such a way that it could serve as a challenge to the group as a whole but should still be feasible if the group were able to combine individual strengths.

This framework was used in different learner grouping scenarios. For instance, see Figure 1 for a user interface suggesting peer helpers for a learning task in mathematics. Accordingly, the architecture of the intelligent subsystem must allow for combining elements from different individual student models. In the original example, individual diagnosis did not require backtracking and modelling was cumulative for all learners at a time. However, diagnosis with backtracking and user interaction needs a more flexible, parallel or multi-threaded architecture. Such architecture has been presented in Muehlenbrock et al. (1998).

Massive practical applications of group formation based on similar principles as described here have been reported by McCalla et al. (1997). An ontology-based representation of group formation principles has been presented by Inaba, Supnithi, Ikeda, Mizoguchi, and Toyoda (2000).

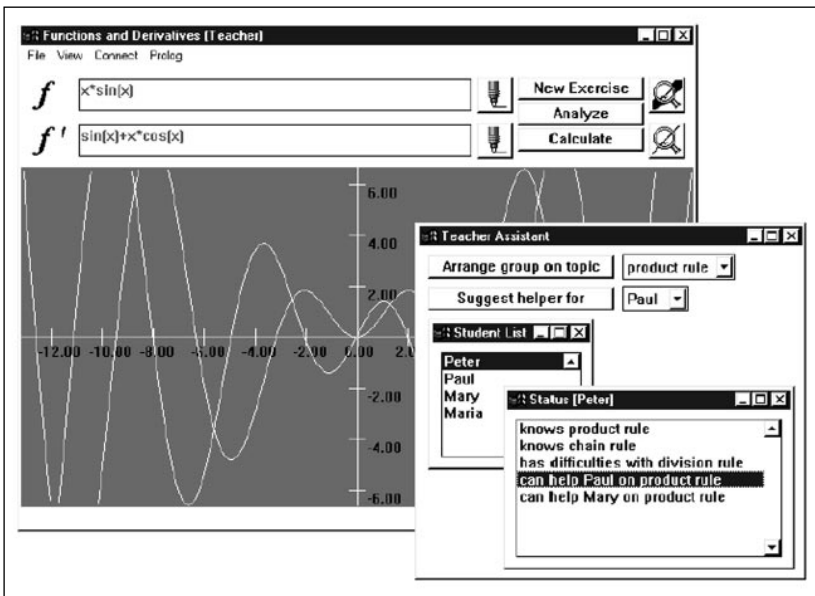


Figure 1. User interface for learning group formation including peer helper suggestion and topic selection

GROUP FORMATION BASED ON LEARNER CONTEXT

The concept of ubiquitous computing envisions a new computing era where computational and communication power is available in devices and objects of every size and purpose (Weiser & Brown, 1995). One of the biggest challenges in ubiquitous computing is the automatic detection of a user context (Salber, Dey, & Abowd, 1999). A typical contextual variable of a user that is frequently addressed is location, driven by many advances in device and sensor technology. Further interesting context features of a user and in a user's environment include, among others, activity, availability, stress, and emotional parameters as well as temperature, noise, weather, colocation of other people, and availability of devices, respectively. For learning group formation, these contextual features provide an additional source of learner information, which could help in improving the quality of the grouping.

Using a networked infrastructure of easily available sensors and context-processing components, an application has been developed for peer helper suggestion and opportunistic group formation based on contextual parameters such as location, activity, and availability (Muehlenbrock, Brdickza, Snowdon, & Meunier, 2004). These notions of location, activity, and availability have both been detected automatically based on sensor information and learned automatically based on users' feedback to the system.

To detect a person's location, activity, and availability, different sensing techniques have been used in a prototypical application. All of these sensors are already available in many environments or can be installed without much effort, such as:

- *PC usage*: Detection of users' keyboard and mouse activity on personal computers.
- *Phone usage*: Detection of phone usage by using a switch connected to an input port of a computer.
- *PDA location*: Determination of the location of user's PDA (personal digital assistant) by using signal strength information related to several base stations.
- *PDA ambient sound*: Detection of ambient sound in the PDAs' surroundings by using the built-in microphone.
- *PDA user feedback*: Explicit feedback on some context variables provided by the users (Figure 2).

The various sensors send their information to a database residing on a server that can be accessed from both the wired and the wireless networks. The database contains static profile data, as well as the dynamic event data. The static profile data may vary over time (e.g., if someone is allocated a new PC or changes office) but comparatively slowly compared to the event

data. The profile data names the entities (people and devices) and places that are referred to by the dynamic event data. Furthermore the profile establishes links between devices and places and people. For example the profile indicates that particular computers, PDAs, and phones are associated with a particular user and that that user has his/her office in a particular place. It also indicates the normal function of places so that our software can find out if a user is in a place that is someone's office or in a public space such as a meeting room or coffee area. The tables associated with the dynamic event data store information about events generated by the sensors and events generated by higher-level components predicting activity and availability.

Figure 2. Feedback on context variables

The context processing consists of combining information from different sources and deriving an estimation of the users' situation. Of particular interest for the application are the activities and availabilities of the users. The set of relevant activities is comprised of single-person activities such as using a PC, using a PDA, and working at the desk, multi-person activities such as phoning, discussing, or being in a meeting, and intermediate activities such as walking from one place to another, which result in a drastic change of context. These activities are assumed to have a major influence on the level of a person's availability. Relevant classes of availabilities that are considered to be useful are being available for a quick question, being available for a longer discussion, being available soon, or not being available at all. By using machine-learning methods the system is to find a connection between sensed information and situations as perceived by users, including also information on people's habits (Muehlenbrock et al., 2004). In order to test the sensing infrastructure and the feasibility of the availability estimation, several one-day experiments have been conducted with different sets of users including typical user situations like PC work, meeting, phoning, and so forth.

SUMMARY

The combination of learning group formation based on information from learner profiles and information on the learner context has a potential of

improving the quality of the grouping. It allows for the adhoc creation of learning groups, which is especially useful for peer help for immediate problems, by reducing the risk of disruptions. It also leverages the forming of face-to-face learning groups based on the presence information.

References

- Hoppe, H. U. (1995). The use of multiple student modeling to parameterize group learning. In J. Greer (Ed.), *Proceedings of the 7th World Conference on Artificial Intelligence in Education*, (pp. 234-241), Washington, DC.
- Inaba, A., Supnithi, T., Ikeda, M., Mizoguchi, R., & Toyoda, J. (2000, August). An overview of "learning goal ontology". In M. Muehlenbrock, (Ed.), *Proceedings of the Workshop Analysis and Modelling of Collaborative Learning Interactions at the European Conference on Artificial Intelligence ECAI-2000*. Berlin, Germany.
- Jermann, P., Soller, A., & Muehlenbrock, M. (2001, March). From mirroring to guiding: A review of the state of art technology for supporting collaborative learning. In P. Dillenbourg, A. Eurelings, & H. Kai Hakkarainen,,: *Proceedings of the European Conference on Computer-Supported Collaborative Learning, EuroCSCL-2001*, (pp. 324-331), Maastricht, The Netherlands.
- McCalla, G. I., Greer, J. E., Kumar, V. S., Meagher, P., Collins, J. A., Tkatch, R., et al., (1997). A peer help system for workplace training. In D. Boulay & R. Mizoguchi (Eds.), *Proceedings of the Conference on Artificial Intelligence in Education AIED 97*, (pp. 183-190), Kobe, Japan.
- Muehlenbrock, M., Brdiczka, O., Snowdon, D., & Meunier, J.L. (2004, March). Learning to detect user activity and availability from a variety of sensor data. In *Proceedings of the Second IEEE Conference on Pervasive Computing and Communications*, Orlando, FL.
- Muehlenbrock, M., Tewissen, F., & Hoppe, H. U. (1998). A framework system for intelligent support in open distributed learning environments. *International Journal of Artificial Intelligence in Education*, 9, 256-274.
- Salber, D., Dey, A., & Abowd, G. (1999, May). The context toolkit: Aiding the development of context-enabled applications. In *Proceedings of the 1999 Conference on Human Factors in Computing Systems CHI 99*, (pp. 434-441), Pittsburgh, PA.
- Weiser, M., & Brown, J., (1996, July). Designing calm technology. *PowerGrid Journal*, 1(1).

Acknowledgement

The work presented in this article is partially supported by European Community under the Information Society Technologies (IST) programme of the 6th FP for RTD - project iClass contract IST-507922