

# An Overview of “Learning Goal Ontology”

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**Abstract.** Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. In this paper, we describe the outline of a system of concepts concerning learning goals expected to attain by learners through collaborative learning process with justification by the learning theories. Then we show an example of usage of the ontology: Opportunistic Group Formation. With the ontology, it will be possible for computer systems and novice educators to form effective collaborative learning groups with justification of learning theories.

Keywords: Ontology, Learning Theory, Group Formation, Learning Goal

## 1 Introduction

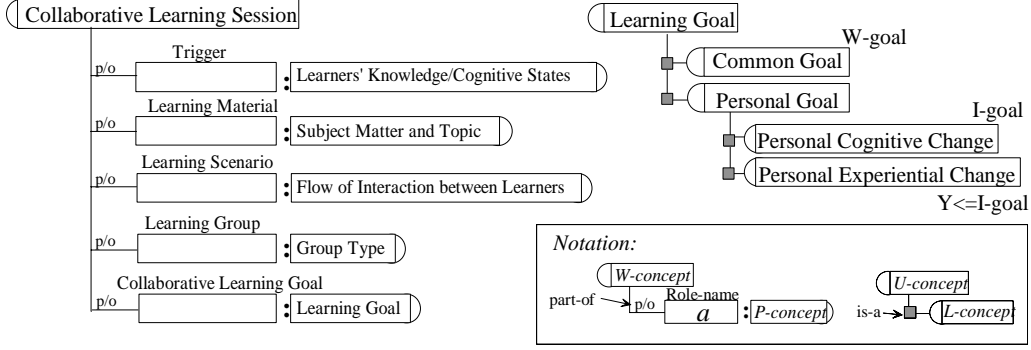
There are many theories to support the advantage of collaborative learning. For instance, Observational learning[2], Constructivism[19], Self-regulated learning[9], Situated learning[15,16], Cognitive apprenticeship[5], Distributed cognition[21], Cognitive flexibility theory[22,23], Sociocultural Theory[25,26], Zone of proximal development[25,26], and so on. If we select a theory from these and form a learning group based on the theory, we can expect effective collaborative learning with the strong support of the theory. A designer should construct collaborative learning support systems taking the learning theories into consideration and represent what he/she intended as an explicit model of design with justification by learning theories. The system designed, on the other hand, needs to understand the model and yields reasonable supporting behavior for collaborative learning based on the understanding. The understanding of learning theories used for justification is, needless to say, partial as compared with what the human expert of learning theories knows. However, we believe the learning theories, even partial, should be modeled as a basis of system design. The problem the system designer faces is caused by difficulty in understanding the learning theories due to the lack of common and solid background concepts for collaborative learning. An ontology represents common concepts of the learning theories as a solid system of concepts. It establishes the shared understanding among designers and systems about the model of collaborative learning which is justified with the learning theories.

In this research we are aiming at building a sophisticated ontology through a survey of existing learning theories. On top of that, our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. To fulfill these objectives, we have to consider the following:

1. How to detect the appropriate situation to start a collaborative learning session and to set up the learning goal,
2. How to form an effective group which ensures educational benefits to the members of the group, and
3. How to facilitate desired interaction among learners in the learning group.

We have discussed item 1 in our previous papers[10,11], and this paper focuses on item 2. When we have clarified item 2 and extracted the desired interaction in the group, we would consider item 3.

We have been constructing a system of concepts to represent collaborative learning sessions supported by these learning theories[12,14,24]. We call the system of concepts “Collaborative Learning



**Fig. 2.** Collaborative Learning Ontology

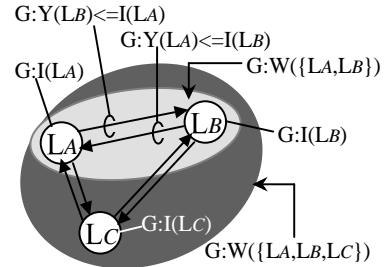
Ontology”. Although advantages of collaborative learning over individual learning are well known, the collaborative learning is not always effective for a learner. Educational benefit that a learner gets through the collaborative learning process depends mainly on interaction among learners. The interaction is partly influenced by relations among members of learning group, which suggests that how to form an effective group for the collaborative learning is critical to ensure educational benefit to the members. In this paper, we focus on “Learning Goal Ontology” which is a part of the Collaborative Learning Ontology. The concept “Learning Goal” is one of the most important concepts for forming a learning group because each learner joins in a collaborative learning session to attain some learning goals.

This paper is organized as follows: we first show briefly the structure of our “Collaborative Learning Ontology”. Then, we describe “Learning Goal Ontology” which is a part of “Collaborative Learning Ontology”. Finally we show an example of usage of our ontology.

## 2 Learning Goal Ontology for Collaborative Learning

Through a survey of studies on collaborative learning, we picked up concepts to represent a collaborative learning session. As a result, we set up five primitive concepts to characterize the session: Trigger, Learning Material, Learning Scenario, Learning Group, and Learning Goal. Fig. 2 shows the conceptual structure of Collaborative Learning Ontology.<sup>1</sup> Here, we concentrate on the concept “Learning Goal”. The “Learning Goal” can be specified as two kinds of goals: “common goal” as a whole group and “personal goal” for each learner. The concept “personal goal” can be specified as two kinds: the goal represented as a change of a learner’s knowledge/cognitive states, and the goal attained by experience of specific interaction with other learners.

We classify the goal of the first person (*I*), that of the first person to interact with the second person (*You*), and that of the whole group as I-goal,  $Y \Leftarrow I$ -goal, and W-goal, respectively. I-goal, which is described as  $G:I$ , represents what a learner is expected to acquire.  $Y \Leftarrow I$ -goal, which is described as  $G:Y \Leftarrow I$ , represents what a learner is expected to acquire through the interaction. W-goal expresses the situation being set up to attain  $Y \Leftarrow I$ -goals and we describe the goal as  $G:W$ . W-goal is a common goal characterizing the whole group.



**Fig. 1.** Learning Goal Ontology

<sup>1</sup> Notation: the schemata define the *W-concept* and the *U-concept*. The *W-concept* has entity “*a*”, which is an instance of the concept *P-concept*, as a part. The entity “*a*” plays a specific role (*Role-name*) in the *W-concept*. The concept *P-concept* has a semicircle on the right sides. It means the concept is defined in other schema. The *L-concept* is a specification of the *U-concept*, and the *U-concept* is a generalization of the *L-concept*.

**Table 1.** W-goals

	W-goal	Definition	Src.
M-PR	Setting up the situation for Peer Tutoring <b>[PT]</b>	Setting up the situation where a learner teaches something to another learner.	[6, 7]
	Setting up the situation for Anchored Instruction <b>[AI]</b>	Setting up the situation where a learner diagnoses another learner's problem and then solve it (Problem-based Learning)	[4]
MSR	Setting up the situation for learning by Cognitive Apprenticeship <b>[CA]</b>	Setting up the situation to learn knowledge or skill as an apprentice	[5]
	Setting up the situation for sharing (Meta-) Cognitive function between learners <b>[SC]</b>	Setting up the situation to share cognitive or meta-cognitive function between learners based on Sociocultural Theory	[25, 26]
	Setting up the situation for sharing Multiple Perspectives <b>[CF]</b>	Setting up the situation to evoke a learner's reflective thinking based on Cognitive Flexibility theory.	[22, 23]
PR-only	Setting up the situation based on Distributed Cognition <b>[DC]</b>	Setting up the situation where full participants, whom knowledge bases are different each other, discuss problems	[21]
	Setting up the situation based on Cognitive Constructivism <b>[CC]</b>	Setting up the situation where full participants discuss problems	[19]
CW	Setting up the community for Legitimate Peripheral Participation <b>[LPP]</b>	Setting up the the community of practice for peripheral participant	[15, 16]
	Setting up the situation for Observational Learning <b>[OL]</b>	Setting up the situation to share other learners' learning processes	[2]

Note: **[\*\*]** means an abbreviation for the W-goal.

e.g., The W-goal "Setting up the situation for Peer Tutoring" is abbreviated as "PT".

Fig. 1 represents learning goals in a group where three learners:  $L_A$ ,  $L_B$  and  $L_C$  are participating. Learner  $L_A$  has an I-goal which is attained through this collaborative learning session and this goal is described in Fig. 1 as  $G:I(L_A)$ . Both  $L_B$  and  $L_C$  have I-goals, and they are represented as  $G:I(L_B)$  and  $G:I(L_C)$  respectively.  $G:Y(L_B) \Leftarrow I(L_A)$  is a  $Y \Leftarrow I$ -goal between  $L_A$  and  $L_B$  observed from  $L_A$ 's viewpoint. In other words, it means the reason why  $L_A$  interacts with  $L_B$ . Concerning this interaction between  $L_A$  and  $L_B$ , there is also a  $Y \Leftarrow I$ -goal observed from  $L_B$ 's viewpoint. That is, it is the reason why  $L_B$  interacts with  $L_A$ . This  $Y \Leftarrow I$ -goal is represented as  $G:Y(L_A) \Leftarrow I(L_B)$ . Both  $G:I(L_A)$  and  $G:Y(L_B) \Leftarrow I(L_A)$  are personal goals of  $L_A$ .  $G:W(\{L_A, L_B\})$  is a W-goal of the learning group ( $\{L_A, L_B\}$ ).  $G:W(\{L_A, L_B, L_C\})$  is a W-goal of the learning group ( $\{L_A, L_B, L_C\}$ ).

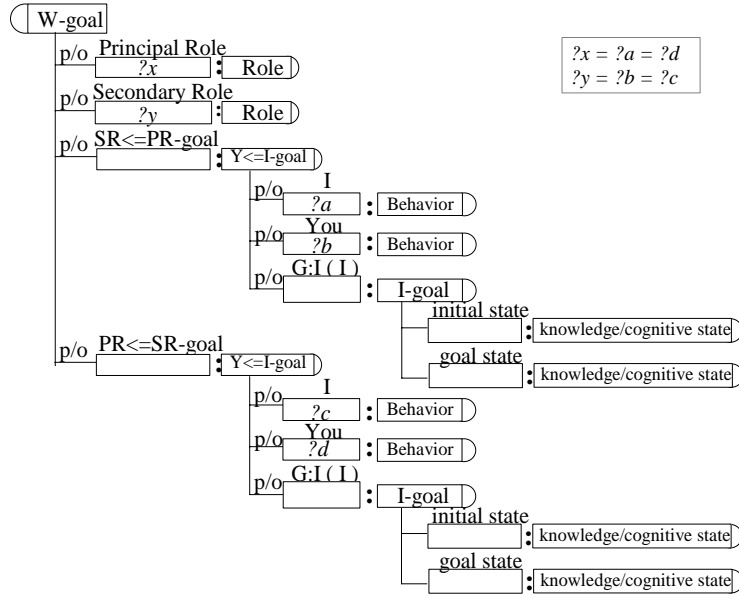
We have identified goals for collaborative learning for each of the three categories, and constructed I-goal Ontology,  $Y \Leftarrow I$ -goal Ontology, and W-goal Ontology with justification based on learning theories.<sup>2</sup> We can expect learners to acquire not only new knowledge concerning problems they solve, but also cognitive skills, meta-cognitive skills, and skills for self-expression through the collaborative learning session (I-goals). Each I-goal has several phases of development. It is difficult to understand from a theory what educational benefit is expected to a learner, because of lack of unified systematic terminology to represent a variety of phases. So, we adopt the terminologies used in two established findings: Rumelhart & Norman's work[20] on knowledge acquisition and Anderson's one[1] for skill development. The process to acquire a specific knowledge includes three qualitatively different kinds of learning[20]: Accretion, Tuning, and Restructuring. Concerning development of skills, there are also three phases of learning: Cognitive stage, Associative stage, and Autonomous stage[1, 8].

The learner is expected to achieve these I-goals through interaction with other learners. For example, to achieve the I-goal "Acquisition of Content-Specific Knowledge (Accretion)", some learners could take the  $Y \Leftarrow I$ -goal "Learning by being Taught[6]", while some learners could take another  $Y \Leftarrow I$ -goal "Learning by Observation[2]".

### 3 Conceptual Structure of Learning Goals

To form a learning group means to pick up learners who join in the group as members and to assign a specific role in the group to each member. The formation should have rationale supported by learning

<sup>2</sup> The details of the ontologies are described in our previous paper[14]. Here, we show the outline of the ontologies.



**Fig. 3.** Conceptual Structure of a W-goal

theories. The structure of learning goals expresses the rationality. A W-goal, which is a learning goal as a whole group, provides the rationale for the interaction among the members. It means that a W-goal specifies a rational arrangement of  $Y \Leftarrow I$ -goals. Table 1 shows the W-goals. The W-goals are classified into four kinds (*i.e.*, M-PR, M-SR, PR-only, and CW) according to their structures. Fig. 3 shows a typical representation for the structure of a W-goal. It would be more easily to understand a learning theory by preparing the structure to represent the theory and filling in each component of the structure with suitable concepts according to the theory.

To describe the specification, we classify the members into two kinds of role-holders: the members who play Principal Role (PR-members) and the members who play Secondary Role (SR-members). Each role is defined as follows:

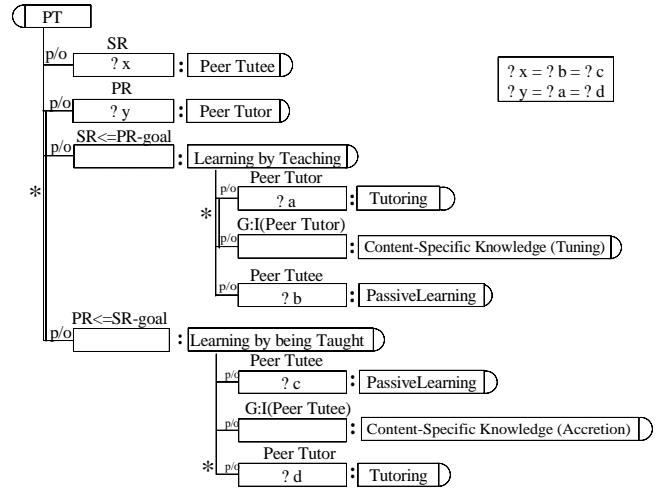
**Principal Role(PR):** the most important role in a collaborative learning session. A PR-member is expected to gain main educational benefit through the session. PR is usually played by the learner who first proposed to have the collaborative learning.

**Secondary Role(SR):** a supporting role for the PR-member. A SR-member helps the PR-member get main educational benefit.

We classify the W-goals into three kinds of W-goals and an exceptional one: Multiple-PR, Multiple-SR, PR-only, and CompositeW. The following classification of the W-goals depends on the number of the components PR and SR.

**Multiple-PR (M-PR):** The W-goal of M-PR type can have multiple PR-members and single SR-member.

**Multiple-SR (M-SR):** The W-goal of M-SR type can have multiple SR-members and single PR-member.



**Fig. 4.** An Example of M-PR type W-goal: PT

**PR-only:** The W-goal of PR-only type has only one role for its members. In this type W-goal, each member joins in a collaborative learning session on an equal footing; they have the same I-goal and the same  $Y \Leftarrow I$ -goal.

The members solve problems and perform assigned tasks in the collaborative learning session. They are expected to get a few educational benefits as secondary effects through the session[13]. For example, a member could develop his/her cognitive skills (*i.e.*, educational benefit), while he/she solves a problem in physics (*i.e.*, assigned task) with other members.

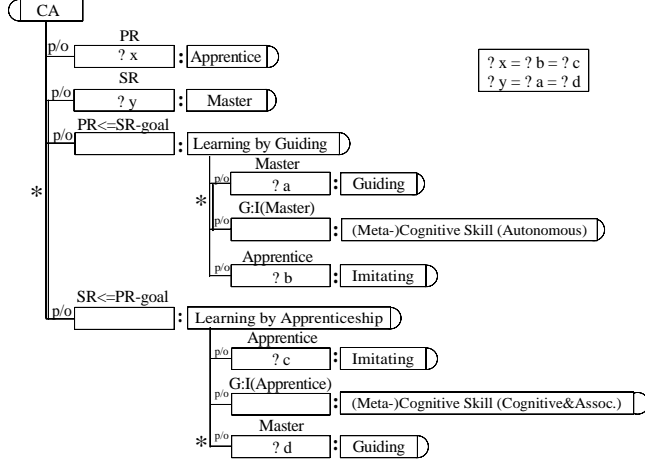


Fig. 5. An Example of M-SR type W-goal: CA

as a M-PR type. Fig. 4 shows the conceptual structure of the W-goal PT. In the figure, the concept marked with \* can generate more than one instance, and the concepts connected with double line generate instances together.

On the other hand, the PR-member mainly solves a problem with the SR-member's help in the M-SR type W-goal. The role of main problem-solver should be assigned to single member, and the role of helper can be assigned to multiple members. Fig. 5 shows the conceptual structure of W-goal Cognitive Apprenticeship as an example of M-SR type W-goal. In the situation of CA, there are two roles: *Apprentice* and *Master*. Main educational benefit is development of a learner's (meta-) cognitive skill by imitating another learner's behaviour[5]. So, PR is identified as *Apprentice* and SR is identified as *Master*. From the viewpoint of assigned task, the role of main problem-solver is *Apprentice*, while the role of helper is *Master*. So, the number of members who play *Apprentice* (PR) should be single, the number of members who play *Master* (SR) can be multiple, and the W-goal CA is identified as a M-SR type.

A group attaining a W-goal( $W_i$ ) can have another group, which has another W-goal( $W_j$ ), as the component SR of the W-goal( $W_i$ ). We call the W-goal( $W_i$ ) "CW-goal" which means a composite W-goal. Fig. 6 shows the conceptual structure of the CW-goal Observational Learning[2]. The learning group has members as *Observers* (*i.e.*, its component PR). The *Observers* require a group (*i.e.*, its component SR) as an object to observe meaningful interaction. In the figure, the W-goal, which is set in #1, depends on what I-goal is set in #2. For

In the M-PR type W-goal, the SR-member mainly solves a problem with the PR-member's help. The PR-member is expected to gain an educational benefit from the experience of helping other member. For example, in the situation of Peer Tutoring, there are two roles: *Peer Tutor* and *Peer Tutee*. Main educational benefit is tuning of content-specific knowledge by externalizing a learner's knowledge[6, 7]. So, PR is identified as *Peer Tutor* and SR is identified as *Peer Tutee*. From the viewpoint of assigned task, the role of main problem-solver is *Peer Tutee* who wants to get a new knowledge to perform assigned tasks, while the role of helper is *Peer Tutor*. So, the number of members who play *Peer Tutee* (SR) should be single, the number of members who play *Peer Tutor* (PR) can be multiple, and the W-goal PT is identified

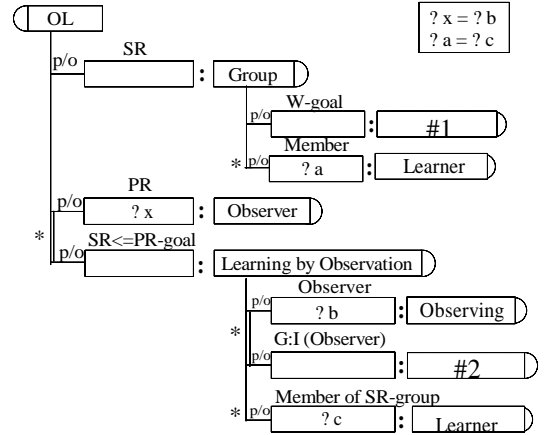


Fig. 6. An Example of CW-goal: OL

example, if the *Observer* sets accretion of content-specific knowledge in #2 as *Observer's* I-goal, the W-goal **PT** is recommended as SR's W-goal (#1).

The body of specification of a W-goal is the rational arrangement of the goals for interaction among the PR-member and the SR-member. A W-goal has two kinds of goals of interaction as follows:

**SR $\Leftarrow$ PR-goal:** a Y $\Leftarrow$ I-goal which means how and for what purpose the PR-member interacts with the SR-member.

**PR $\Leftarrow$ SR-goal:** a Y $\Leftarrow$ I-goal which means how and for what purpose the SR-member interacts with the PR-member. In the collaborative learning session, all members of learning group are expected to get some educational benefits. So, the SR-member also has an I-goal, and the PR $\Leftarrow$ SR-goal should be effective to attain the I-goal.

The entities of these goals refer to the concepts defined in the Y $\Leftarrow$ I-goal Ontology. The conditions, which are proper to each W-goal, can be added to the concepts, if necessary. Each of the Y $\Leftarrow$ I-goals referred to by SR $\Leftarrow$ PR-goal and PR $\Leftarrow$ SR-goal consists of three components as follows:

**I:** a role to attain the Y $\Leftarrow$ I-goal. A member who plays I role (I-member) is expected to attain his/her I-goal by attaining the Y $\Leftarrow$ I-goal.

**You:** a role as a partner for the I-member.

**G:I:** an I-goal which means what the I-member attains.

Each W-goal can be expressed by a set of Y $\Leftarrow$ I-goals and I-goals. We can identify a group formation to start an effective collaborative learning session with these goals.

## 4 An Example of Usage of Learning Goal Ontology: Opportunistic Group Formation

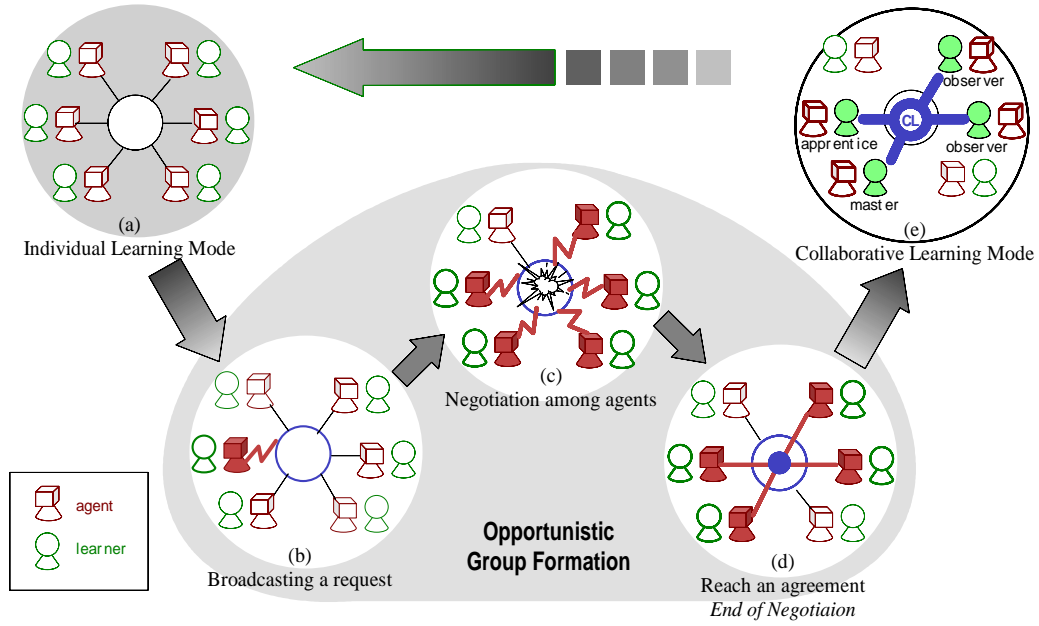
In this section we describe an example of usage of our learning goal ontology. We have been developing a multi-agent system to support collaborative learning dynamically based on the idea of *Opportunistic Group Formation (OGF)*[10, 11]:

*Opportunistic Group Formation* is a function to form a collaborative learning group dynamically. When it detects the situation for a learner to shift from individual learning mode to collaborative learning mode, it forms a learning group each of whose members is assigned a reasonable learning goal and a social role which are consistent with the goal for the whole group.

Here, we describe the outline of the collaborative learning support system which we call FITS/CL. Fig. 7 shows the overview of the function of FITS/CL.

In Fig. 7 (a), each learner is solving problems individually under a tutoring function of FITS/CL. An agent takes charge of monitoring a learner and tries to get the benefit for its own learner by considering the personal goal. When the agent detects a desired situation for its own learner to switch into collaborative learning mode based on its learner model, the agent will initiate the negotiation process in order to form a learning group. At the same time, the agent establishes a learning goal, and proposes a learning group formation, the learner's role in the group, and learning topics to be addressed in the session. This information is broadcasted to other agents as a request for forming a collaborative learning group (Fig. 7 (b)). Only the agents that can get the benefit through collaborative learning session for their own learners will participate in the negotiation process between agents (Fig. 7 (c)). The agents are connected each other in order to negotiate for collaborative learning session. Each agent considers the personal benefit for its own learner while it considers the social benefit for the whole group. Each agent can form a learning group formation appropriate for its own learner, and negotiates for the most effective learning group for the most learners. In the negotiation process, opinion exchange, persuasion, compromise and criticism action will be selected to use in order to overcome the conflict among agents.

When the negotiation completed successfully (Fig. 7 (d)), a new communication channel is opened for the members of the learning group (Fig. 7 (e)). The members can freely communicate with each



**Fig. 7.** The overview of the function of FITS/CL

other through the channel by using natural language. The agents only send some messages via a dialog box in order to give an explanation about how to collaborate in the initial phase and wait until the members achieve the goal. Each member is well informed of the learning goal as a whole group and the role assigned to him/her. Each member plays one specific role in a collaborative learning session. The agents in any sense do not monitor the communication among members. When the achievement of the learning goal is declared by one of the members, the agents close the channel among the members and ask the members the outcome of the collaborative learning in order to evaluate their achievement. Each agent updates the learner model based on the evaluation and encourages the learner under its charge to reopen his/her learning task in individual learning mode. The agents communicate each other with a protocol based on KQML[11].

In FITS/CL, each agent should have an ability to realize the following functions:

1. Setting up appropriate learning goals for a learner,
2. Forming learning group to enable the learner to attain the learning goals, and
3. Negotiating with other agents to reach an agreement: a formation of collaborative learning group that each member of the group can get educational benefit.

It is hard to realize the function 2 for the agents, even if each agent can realize the function 1 based on its learner model. Our learning goal ontology will make a contribution to the function 2. The agents only look for the W-goals which include a specific I-goal as their component. Concerning the function 3, the agents cannot negotiate or reach an agreement if there is no criterion for the educational benefit. Our learning goal ontology enables the agents to infer educational benefit before the collaborative learning session starts, and justifies the agent's proposal by learning theories.

## 5 Conclusion

We have discussed Learning Goal Ontology which will be able to make it easier to form an effective collaborative learning setting and to analyze the educational functions for a learning group. By considering the personal and common goals, we have identified three kinds of learning goals; I-goal,  $Y \Leftarrow I$ -goal and W-goal. In this paper, we described the outline of Learning Goal Ontology.

At this stage, we mainly focus on the learning goals. Future work includes to construct ontologies on remaining concepts in Collaborative Learning Ontology. Advantage of collaborative learning includes emotional factors: *e.g.*, motivation, familiarity. It is also our future work how to treat these factors.

## References

1. Anderson, J.R. (1982) Acquisition of Cognitive Skill, *Psychological Review*, vol.89(4), pp.369-406.
2. Bandura, A. (1971) *Social Learning Theory*. New York: General Learning Press
3. Bransford, J. D., Vye, N., Kinzer, C., & Risko, R. (1990) Teaching thinking and content knowledge: Toward an integrated approach. In: B. Jones & L. Idol (Eds.) *Dimensions of thinking and cognitive instruction*. Hillsdale NJ: Erlbaum. pp. 381-413.
4. Cognition and Technology Group at Vanderbilt. (1992). Anchored instruction in science education. In: R. Duschl & R. Hamilton (Eds.), *Philosophy of science, cognitive psychology, and educational theory and practice*. Albany, NY: SUNY Press. pp. 244-273.
5. Collins, A. (1991) Cognitive apprenticeship and instructional technology. In: Idol, L., & Jones, B.F. (Eds.) *Educational values and cognitive instruction: Implications for reform*, Hillsdale, N.J.: L. Erlbaum Associates.
6. Cooke, N.L., Heron, T.E., & Heward, W.L. (1983) *Peer tutoring: Implementing classroom wide programs*. Columbus, OH: Special Press.
7. Endlsey, W.R. (1980) *Peer tutorial instruction*. Englewood Cliffs, NJ: Educational Technology
8. Fitts, P.M. (1964) Perceptual-Motor Skill Learning. In: Melton, A.W. (Ed.), *Categories of Human Learning*, New York: Academic Press. pp.243-285.
9. Flavell, J. H. (1976) Metacognitive aspects of problem-solving. In L.B. Resnick (Ed.), *The nature of intelligence*. Hillsdale, NJ: Erlbaum. pp.231-235
10. Ikeda, M., Hoppe, U., & Mizoguchi, R. (1995) Ontological issue of CSCL Systems Design, *Proc. of AI-ED 95*, pp.234-249.
11. Ikeda, M., Go, S., & Mizoguchi, R. (1997) Opportunistic Group Formation, *Proc. of AI-ED 97*, pp.166-174.
12. Inaba, A., Ikeda, M., Mizoguchi, R., & Toyoda, J. (1999) The Learning Goal Ontology for Collaborative Learning. <http://www.ai.sanken.osaka-u.ac.jp/~inaba/LGOntology/>
13. Inaba, A. & Okamoto, T. (1997) The Intelligent Discussion Coordinating System for Effective Collaborative Learning – What is the role of artificial intelligence in supporting collaboration? –, *AIED 97: Workshop Notes IV*, pp.26-33.
14. Inaba, A., Supnithi, T., Ikeda, M., Mizoguchi, R., & Toyoda, J. (2000) How Can We Form Effective Collaborative Learning Groups? – Theoretical justification of “Opportunistic Group Formation” with ontological engineering –, *to appear*, <http://www.ai.sanken.osaka-u.ac.jp/~inaba/Doc/its2k-cr.pdf>
15. Lave, J. (1988) *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge University Press.
16. Lave, J. & Wenger, E. (1991) *Situated Learning: Legitimate peripheral participation*. Cambridge University Press.
17. Mizoguchi, R., & Bourdeau, J. (2000) Using Ontological Engineering to Overcome Common AI-ED Problems, *IJAIED*, 11, *to appear*
18. Mizoguchi, R., Ikeda, M., & Sinita, K. (1997) Roles of Shared Ontology in AI-ED Research, *Proc. of AI-ED 97*, August, Japan, pp.537-544.
19. Piaget, J., & Inhelder, B. (1971). *The Psychology of the Child*. New York: Basic Books.
20. Rumelhart, D.E., & Norman, D.A. (1978) Accretion, Tuning, and Restructuring: Modes of Learning., In: Cotton, J.W., & Klatzky, R.L. (Eds.) *Semantic factors in cognition*. Hillsdale, N.J. : L. Erlbaum Associates., pp.37-53.
21. Salomon, G. (1993) *Distributed cognitions*, Cambridge University Press.
22. Spiro, R. J., Coulson, R., L., Feltovich, P. J., & Anderson, D. K. (1988) Cognitive flexibility: Advanced knowledge acquisition ill-structured domains. *Proc. of the Tenth Annual Conference of Cognitive Science Society*, Erlbaum, Hillsdale, NJ, pp.375-383.
23. Spiro, R. J., Feltovich, P., J., Jacobson, M., L., & Coulson, R. L. (1995) Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. <http://www.ilt.columbia.edu/ilt/papers/Spiro.html>
24. Supnithi, T., Inaba, A., Ikeda, M., Toyoda, J., & Mizoguchi, R. (1999) Learning Goal Ontology Supported by Learning Theories for Opportunistic Group Formation, *Proc. of AIED99*.
25. Vygotsky, L.S. (1929) The problem of the cultural development of the child, II. *Journal of Genetic Psychology*, vol.36, pp.414-434.
26. Vygotsky, L.S. (1930) *Mind in Society: The development of the higher psychological processes*. Cambridge, MA: Harvard University Press. (Re-published 1978)