

Understanding the Collaborative Learning Process in a Technology Rich Environment: The Case of Children's Disagreements

Marion A. Barfurth

*Département des sciences de l'éducation
Université du Québec à Hull*

Abstract

Recognition of the importance of the social role in learning combined with the advancement of educational applications of computer technology has sparked the development of innovative learning situations. The resulting increased complexity in the social context in which the learning is occurring requires a more in-depth understanding of the learning process. Collaborative learning is gaining in popularity but we still need to establish what is meant by it and gain insight into its process. This paper proposes an innovative analytical framework for viewing the collaborative process. It reports on a study with elementary school aged children working with LEGO/Logo and their evolving understanding of the scientific concept of mechanical advantage. It comes as little surprise that children learning collaboratively is not always as collaborative as one might have expected. In fact, in this study disagreements arose frequently. Some of the findings are reported and support the view that disagreements can be a legitimate form of collaboration.

Keywords — Collaborative learning, situated learning, disagreement, learning process, conceptual change, LEGO/Logo, mechanical advantage, science education, classroom-based research, elementary school.

1. Introduction

Two important theoretical changes with respect to learning are at the root of the increasing interest in learning environments that provide computer support for collaborative learning. The first is the view of learning that considers both the social context and the social processes as an integral part of the learning activity (Brown, Collins, & Duguid, 1989, Greeno & Moore, 1993, Lave & Wenger, 1991, Resnick, 1991, Rogoff & Lave, 1984). The second is the recognition

of the importance of learners actively constructing their knowledge as suggested by the theoretical viewpoint of constructivism.

The creation of learning environments that renders learning more active and in a more social context is initiating new challenges for research on learning. The combination of active learning and technology is creating learning situations that were, until very recently, unavailable for furthering our study of the learning process. Learning taking place in more social contexts, such as collaborative learning, is gaining in popularity both in classroom practice and research. Yet, very little is actually known about the process itself.

In the area of science and mathematics education the importance of active learning and in more social contexts is well asserted in the literature (Gardner, Greeno, Reif, Schoenfeld, diSessa, & Stage, 1990, Putnam, Lampert, Peterson, 1990). This change is extremely important as it necessitates the need for improving the examination of the learning process in these domains. Greeno (1990) suggests that: "Most research in science education treats learning in science as something that an individual student does. . . . we researchers of science education need to learn how to study the social phenomena of learning and understanding scientific concepts" (p. 181).

The developmental theories of both Piaget and Vygotsky provide interesting insight into the role of social interaction on cognitive growth. Their views differ in that for Piaget, social interaction is seen from the perspective of its role in the development of logical reasoning. While, for Vygotsky, social interaction is at the core of the developmental process and children's learning. In his theory, individual cognitive development is a process related to transforming socially regulated and mediated knowledge. See Confrey, (1994, 1995) and Tudge and Rogoff (1989) for a more detailed analysis of these two theories.

Resnick (1991) underlines the importance of looking at the influence of social interaction (e.g. asking questions, arguing, the elaboration of one's ideas) on the constructive process. She points out that there is a need to "seek mechanisms by which people actively shape each other's knowledge and reasoning processes" (p. 2). Technology rich environments are providing new opportunities for learning to occur in much more social contexts. In the emerging CSCL community, Pea (1994) suggests that we need "to be deeply conscious about the birth of CSCL as a discipline and a new approach to thinking about learning and education" (p. 297).

Both the use of the terminology and the criteria for establishing a collaborative learning situation vary in the literature. Looking at the terminology, terms used to describe collaborative learning include "peer collaboration" (Tudge & Rogoff, 1984), "collaborative learning" (Forman & Cazden, 1985), "coordinated learning" (Koshmann, 1994), and "collective learning" (Pea, 1994). Pea provides an insightful reflection when he argues for his choice of terms: "not all learning feels or probably is collaborative; it is sometimes competitive or coercive in nature" (p. 286). It is interesting to note this evolution of terms and the breadth of meaning that the terms are capturing in order to more realistically reflect the interactions among active learners.

The criteria for establishing a collaborative learning situation are also evolving. Forman and Cazden (1985) distinguished collaborative learning from other forms of peer interaction based on the task being performed. For them, "collaboration requires a mutual task in which the partners work together to produce something that neither could have produced alone" (p. 329). Tudge and Rogoff (1989) distinguished studies on peer collaboration from other studies on peer interaction on the basis of their focus on the actual process as opposed to just outcomes. This reflects the changing view of research on learning and the type of environments used to study the learning process.

In contrast to traditional classroom group work that is often artificial and imposed, collaboration in technology rich environments offers the potential for genuine collaboration to occur. The collaboration is genuine because collaborating with others is an optimal and desired form of working. An example of genuine collaboration in everyday life are emergency situations. Something happens (an earthquake, a bus accident) and total strangers work together to provide help, establish priorities, plan for the next move, organize others etc. There is a shared goal and the optimal solution is attained by working with others. In this paper, collaborative learning is viewed as working with others towards a common goal. The focus is on the process and more specifically the process as it occurs during disagreement between the collaborators.

Research on collaborative learning that focuses on the process rather than outcome is both recent and lim-

ited. It includes in the sociolinguistic tradition, work by Forman and Cazden (1985) that looked at social interactional patterns (parallel, associative, cooperative) and problem-solving strategies (random combinations, isolation of variables, systematic combinatorial strategy) during group problem solving. Part of their results showed that the most cooperative interactions that used the most combinatorial strategies solved the most problems. However, the pretest-posttest comparison did not show such clear benefits. Tudge (1990) raised an interesting question with respect to peer-peer interaction. Although the research on collaboration with peers often indicated cognitive advancement (Doise & Mugny, 1984, Perret-Clermont, 1980), Tudge showed that in certain circumstances peer interaction could result in development as well as regression.

Roschelle (1992) did a micro-analysis of the collaborative process to look at the convergence of meaning while learning science. The collaborative process in his work was examined as a continuous series of interactions. He looked at the collaborative process using an innovative simultaneous approach in which several perspectives of the same act were used for analytical purposes. These were: a) conversational action, b) the conceptual change from a cognitive perspective, and c) the shared knowledge from a social perspective. Roschelle was able to show that a conceptual change occurred and that the "students arrived at a common shared new conceptualization" (p. 264). He described the process as being incremental, interactive and social.

Disagreements, although not always welcomed, are to be expected as learning becomes more active and social. The research tradition on children's disagreements typically examines them from an interpersonal perspective and, given the low tolerance for conflict in elementary school, focuses mostly on very young children (Shantz, 1987). Very little is known about substantive disagreement that occurs in a naturalistic learning setting.

2. The Study

The study looked at children's collaboration in a design and construction environment (LEGO/Logo) in which children had the opportunity to create and produce robotic inventions (Papert, 1986). The LEGO/Logo activities were integrated into the science and computer curriculum in a regular classroom. They took place twice a week for a duration of 45 minutes. The particular task that the children were working on was to build something that had a mechanical advantage (Barfurth & vanGelder, 1993, 1994, vanGelder & Barfurth, 1993).

In addition to coming up with ideas, during this five week project, the children also had to coordinate different ideas during the different stages of the design process. This study focused specifically on the dis-

agreements the children had during the designing and building stages for their invention. The topics of the disagreements deal with structural, mechanical and physics problems implicit in the construction process.

One group of four children were randomly chosen from those groups in which all four children had consented to participate. The project combined children from a grade four and five classroom; each working group was composed of two children from each grade level. As it turned out, the group selected had a grade four and five girl and a grade four and five boy. One group of four children (2 from grade 4 and 2 from grade 5).

The principal data collection tool was a video camera placed on a tripod next to the group of four children. The video recordings were then transcribed. A qualitative data analysis program was used to help in the management of the data.

2.1. The analytical framework

The analytical framework presented in this study was designed to look at the collaborative learning process from two perspectives the social and the cognitive. The theoretical foundation for this analytical framework grows out of the more recent research that looks to both Piagetian and Vygotskian theories to further the understanding of peer interaction. Forman made an interesting suggestion with respect to the different perspectives of peer interaction as seen in the theoretical frameworks of both Piaget and Vygotsky.

Forman (1987) noted theoretical differences in the cognitive and social processes underlying collaborative problem solving in Piaget's and Vygotsky's theories. In Piaget's theory the parallels between cognitive and social processes are explained by the fact that both derive from the same central intrapsychological process, whereas in Vygotsky's theory the correspondence is due to the derivation of individual higher cognitive processes from joint social processes. These differing interpretations are accompanied by differences in the mechanism: intersubjectivity and perspective-taking. Forman suggested that intersubjectivity (from the Vygotskian perspective) is a process that takes place across people, whereas perspective-taking and decentering (from the Piagetian perspective) are individual processes working on socially provided information.

(Tudge & Rogoff, 1989, p. 29)

The differences in the mechanisms (intersubjectivity and perspective-taking) referred to by Forman in the above citation form the basis for the proposed analytical framework. The notion of a **social**

move and a **cognitive move** is introduced to operationalize these two different perspectives.

The social move: One way of viewing the social (in the sense of intersubjective) perspective of the collaborative process would be to examine the process, as it occurs, across the participants. In other words, given a group of participants, this perspective looks at the process from the group as a whole and the interactions that occurred as a sequence between them. The notion of sequence is introduced to preserve the order in which the interactions occur between the participants.

The coding schema used to denote a social move is based on the structural analysis of disagreements done by researchers working in a sociolinguistic tradition (Eisenberg & Garvey, 1981; Genishi & Di Paolo, 1982; Wilkinson & Martino, 1993). The structure for a disagreement recognizes four basic components: an antecedent, opposition, resolution move, outcome.

A **cognitive move** partially reflects the other mechanism that Forman suggests above, that of the individual processes working on socially provided information. There are two working assumptions underlying the development of the concept of a cognitive move. These are:

- (1) During social interaction a parallel individual cognitive process is taking place.
- (2) (a) Each and every social act reflects an individual's cognitive act.
- (b) This cognitive act can be identified.

A cognitive move therefore reflects the cognitive act that a person does in light of the social interaction. Unlike the social move that takes the perspective of across-people and from the group as a whole, a cognitive move is from the perspective of the individual and what this individual does in light of the information provided during the social interaction. Similar to the social move, the notion of sequence is introduced to preserve the order in which the cognitive moves take place both between the participants as well as for a given participant. Keeping the cognitive move relative to the social move as well as to the event itself allows for a more extensive analysis to be undertaken.

This coding schema was developed to capture the different cognitive moves that the individual children used while disagreeing during their collaborative work. These moves reflect the different options that the children had with respect to the information put forth by others during the disagreement. What follows is a description of the principal cognitive moves:

Initiate a topic: Make an explicit statement with respect to a particular topic. Example:

Patricia: [sliding axle through] Well maybe it will jam. [Turning] See it still doesn't touch. So we can't use a small one, Jeff. I told you we had to use a medium.

Add a new aspect with respect to the initiated topic: Contribute new or additional (could have been previously seen but not necessarily in the immediate) information about the topic at hand. Example:

Patricia: Oh [testing and turning] it's these. This [first two axles] works. It's this one that jams it [pointing to third axle].

Integrate others' position with yours: Taking into consideration what someone else has put forward on a topic. This newly integrated information could be correct as it could be incorrect. Example:

Filene: Instead of putting this one [points to third axle small gear] try that [points to fourth axle medium gear]

Patricia: O.K. Let's try [pulling off third axle]. [Answering Kenny's and Jeff's question of what are we doing right now?] Cause Filene got the idea that since it's the small gear that is so hard to turn// [Patricia is cut off].

Modify your own position: Having heard what someone else has put forward or having experimented with the material, you modify your own position. This modification could be major or minor. It could also result in a correct or incorrect outcome with respect to knowledge on the topic.

Patricia: [Finishing to re-install the second axle.] There, now it turns [Turning it, the first two axles turn and the last three do not.] Oh, it's these [pointing to the last three axles] This works [the first two axles].

In this example, based on her observations with the material, Patricia put forward a new hypothesis that it was the last three axles that were a problem because the first two worked. She modified her content based on her experience.

Maintain the same position: No change in the position held with respect to the topic under disagreement. This includes the situation in which one is not taking into account what other's are saying or disagreeing with what has been put forward. It can have the form of repeating what one has just said or paraphrasing. The example below illustrates Jeff maintaining his position over a segment of a disagreement.

1. Jeff: *It doesn't make a difference [maintains his position]*

5. Jeff: *It's hard to turn it. That's the reason. It's because it's hard to turn it. [paraphrasing]*

12. Jeff: *You need a small gear to turn the big gear. [same position more explanation]*

Ask for an explanation or clarification: A child explicitly asks for an explanation or clarification during the disagreement.

3. Jeff: *What difference will it make where it is?*

Quit altogether or take an observatory role: A child discontinues their participation in the disagreement.

Jeff: *Look, you'll do everything and I'll watch. O.K.?*

Kenny: *I'm going to sleep [puts his head down on his folded arms.]*

Table 1. Example of a Coded Disagreement.

Utterance	Social move	Cognitive move
0. Patricia: and then 'cause. You know what we could do, we could put a big gear here like another big gear	Antecedent	Initiate a topic
1. Kenny: No, it will slow it down.	Initial opposition	Add a new aspect
2. Filene: We don't have any big gears	Resolution	Add a new aspect
3. Kenny: Plus we don't have it. Plus it will ooh	Opposition-asserts alternative position	Modify position
4. Patricia: we could put the small one attached here [points to first axle large gear] and here [looks like the second axle medium gear]	Resolution	Add a new aspect
5. Kenny: [Playing with black LEGO chain] But the big gear, if we put a big gear it will go much slower cause the big gear ahh is much slower. If we add a big gear here [points to third axle area] it won't go as fast Filene. Believe me.	Opposition-asserts alternative position	Add a new aspect
6. Filene: Oh because this one [nods her head] I get it.	Resolution	Integrate other's position
7. Kenny: No, because the big gears are slower. Some girls are just//	Opposition-asserts alternative position	Maintains same position
8. Patricia: [Is sliding a fourth axle onto the invention with the small gear on the inside] No [to K], but this one [points to small gear] attached to the big gear will go even faster.	Outcome	Add a new aspect

Following each utterance in the second column is a label that uses the general structure of a disagreement to look at the social move perspective. The disagreement begins with Patricia making a suggestion to add another large gear to the string of four gears on three axles that they already have. The gears are set up as follows: first axle a large, second axle a medium touching the large and another large touching the medium gear on the third axle. Kenny disagrees and asserts an alternative position, saying it will go more slowly. Filene, locates the evidence that, in any case, there are no more large gears in their storage box. This is a move towards a resolution. This is then followed by a series of resolution moves during which Patricia proposes alternative possibilities and Kenny continues his initial opposition. The disagreement terminates with Patricia making and executing a new suggestion while Kenny and Filene get distracted.

In this example, the cognitive move reflects what each child has done from his or her individual perspective, in light of what the others said and did during social interaction. The first utterance (0), from a social perspective, was an antecedent to the disagreement. Looking at this same event, only this time from the individual's cognitive perspective Patricia has initiated a topic to their discussion. Kenny (2) from the social perspective, opposed Patricia, while from a cognitive perspective, he has added a new aspect to the discussion. Filene (3) in an attempt to resolve the disagreement, added a new aspect (that there are no more large

gears). This was followed by Kenny who continued to oppose, but from a cognitive perspective has modified his position to take into account Filene's contribution. The disagreement continues with another resolution move (4) and opposition (5) during which, Patricia and Kenny each added new information about the topic being discussed. Filene (6) provided an example of integrating another participant's position while Kenny (7) continued to maintain his position and Patricia added another new information.

2.2. Analysis and a summary of some of the results

In order to gain more insight into the process of collaborative learning, the children's social and cognitive moves were examined from three different perspectives. These are independently, in parallel and sequentially. Each perspective sheds a different light on the process. Looking at the moves independently reveals the composition of the disagreements from a social and cognitive move perspective. In parallel, it reveals the cognitive moves taking place during the social moves. Sequentially it allows one to see if certain moves incite others during the disagreements.

A total of 24 substantive disagreements were identified while working on their second invention that covered a 5 week period. The results indicate that:

- The children were able to discuss, defend, modify and actively seek solutions during disagreements.
- The children did more than oppose each other. They attempted to resolve their oppositions.
- The opposition during a disagreement was more than negation. The children insisted on explanation and evidence as they worked on their shared task.
- The resolution process of the disagreements included integrating other children's ideas, modifying their own ideas and asking others for clarification and explanation.

3. Conclusion

The proposed analytical framework that looked at social moves and cognitive moves from a parallel perspective proved to be very useful for gaining access to the collaborative process while learning. Although an extreme case of collaboration was used in the application of this framework, it served well for demonstrating the power and the potential of this approach. Clearly, the framework needs further development to be able to accommodate other types of collaborative interaction. As suggested in Roschelle's (1992) study and now in this one, the notion of simultaneously looking at the same act but from different perspectives seems an interesting approach to furthering our access and, in turn, understanding of the collaborative process.

The conclusions with respect to the collaborative process and children's disagreements suggest that a) children's disagreements can be viewed as a legitimate source of collaboration and b) children's disagreements can be both constructive and productive in the learning process. Children's disagreements appear to hold an important role in active learning. How we accommodate these, as well as other types of collaborative interaction, is an important consideration for future research on learning. As we broaden the scope of collaborative learning together with the CSCL environments to support it, we need to enhance the ways in which learning is understood.

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Author's Address

Marion A. Barfurth: Département des sciences de l'éducation, Université du Québec à Hull, Case Postale 1250, succursale "B", Hull Québec, Canada, J8X3X7. (819) 595-4404 Fax: (819) 595-4459 BARFURTH@UQAH.UQUEBEC.CA.