The Polyphonic Model of Hybrid and Collaborative Learning[1]

Stefan Trausan-Matu

Politehnica University of Bucharest, ROMANIA

Abstract

This chapter presents a model for hybrid and collaborative learning based on an analogy with musical polyphony, starting from Bakhtin's ideas of dialogism. The model considers different voices (participants) inter-animating and jointly constructing a coherent tune (a solution, in problem solving), enabling other voices to adopt differential positions and to identify dissonances (unsound approaches). This chapter introduces also software tools, which visualize the discussion threads in a chat and the influences that an utterance has on the subsequent ones. Such tools help both teachers and learners to evaluate and enhance the learning process. The model helps to understand how learners inter-animate when they participate to collaborative chats for problem solving or other learning activities, including Hybrid Learning.

INTRODUCTION

In recent years, collaborative tools on the web, like message forums, instant messengers (chats, for example, Yahoo messenger with two or more participants), wikis, blogs and folksonomies became very popular, adding a new dimension to the web and bringing a new generation, Web2.0. It is very important that this new generation appeared before the generation expected by many: the semantic web. This fact is very significant because it emphasizes also theoretical issues important for learning theory and practice: The socio-cultural paradigm ("knowledge is built socially") of Web2.0 is now much more successful in the competition with the cognitive paradigm ("knowledge is acquired individually"), which fundaments the semantic web and Artificial Intelligence (AI).

These different two paradigms have direct correspondence also in the way we see and support learning with computers. Instead Computer-Based Learning or Intelligent Tutoring Systems (ITS), two leading paradigms of the last decades, we discuss now about Hybrid Learning and Computer-Supported Collaborative Learning (CSCL, see also Koshmann, 1999). Moreover, even the appearance of the idea of Hybrid Learning may be explained also by the failure of the ideas that learning is only a knowledge transfer process that may be achieved individually, solely with the use of totally online learning. Meanwhile, the difficulties of achieving artificial intelligence in the strong sense (totally

imitating humans) leave far away the ideal of totally replacing professors by artificially intelligent assistants (as, for example, ITS supporters hoped).

The analysis of the problems in achieving strong AI has an important significance for this chapter because it emphasizes the role and specific features of dialog. The famous Turing test of AI (Turing, 1950), which was not passed yet, is in fact verifying if a computer program may enter into a dialog with a human exactly like a human. The difficulty of developing computer programs that enter into a dialog with humans suggests us to leave humans to dialog themselves, inclusively for learning purposes. This chapter is focusing exactly on this kind of communication, and it has as a main goal to analyze what happens in human dialogs for learning and to see how dialog may be used by small groups of students for learning collaboratively in chat conversations.

The last years showed that the use of chat conversations in Computer-Supported Collaborative Learning proved to be an effective way of complementing traditional classroom teaching (Stahl, 2006), being well suited also for Hybrid Learning. The polyphony theory and the associated model of inter-animating voices are empowering the achievement of these aims, encompassing both written (be it in chat or in manuals or web documents) and spoken human language (e.g. in classroom learning). Consequently, even a theory of Hybrid Learning may be developed in this idea: The voices of professors enter in polyphony with those of the students both in classrooms and collaborating using online tools.

It is a consensus that CSCL belongs to a socio-cultural approach, based on the ideas of Vygotsky (1978). However, these theories do not capture the peculiarities of the conversational, dialogical nature of collaboration in CSCL. Consequently, several researchers (Koshmann, 1999; Stahl, 2006; Trausan-Matu & all, 2006; Trausan-Matu & all, 2007b) proposed dialogism as a basic model of CSCL. Dialogism is Bakhtin's theory that everything, spoken or written, is a dialog (1973, 1981). Starting from dialogism, more elaborated theories and models may be developed, based also on the polyphony idea introduced also by Bakhtin (1973). In addition, software tools may be developed for supporting chat-based CSCL, starting from the polyphonic perspective (Trausan-Matu & all, 2006, Trausan-Matu & all, 2007a; Trausan-Matu & all, 2007b).

The goals of this chapter are to analyze the particularities of discourse in CSCL conversation chats, to propose a theory for the inter-animation processes that occur and to present some tools for supporting this kind of learning. The achievement of all these goals is based on a unitary conception on linguistic interaction based on dialogism and polyphony, in conjunction with a socio-cultural perspective on learning. Moreover, the polyphonic model may be considered also as encompassing Hybrid Learning in general, because the same ideas apply not only to online chat, but also, for example, to transcripts of spoken dialogs in classrooms.

For the illustration of theoretical ideas with examples, we will use chats from two series of experiments. A first series of chats is taken from Hybrid Learning sessions performed with computer-science students in the final year at the Politehnica University of Bucharest, at a Human-Computer Interaction course, as a part of the Romanian CNCSIS K-teams (http://www.k-teams.cs.pub.ro/) and EU-FP7 LTfLL (http://partners.ltfll-project.org/) projects. As homework to the collaborative interfaces class lecture, students had to discuss using an instant messenger (chat) system about what facilities and tools should have a collaborative environment. In order to animate the

discussions and to force the students to debate with arguments different collaborative techniques, each student had to take the role of a director of a software company supporting forums, chat, wiki and respectively blog. Moreover, they had to conclude their discussion with the proposal of an integrated environment, which would combine the all four techniques. All the chat groups had 4 participants, chatting either in English (as non-native language) or Romanian.

A second series of experiments from which several excerpts were taken consists in chats for mathematics problem solving, investigated in the Virtual Math Teams (VMT) project at Drexel University (http://www.cis.drexel.edu/faculty/gerry/vmt/).

The next section will make a first encounter with the particularities of chat conferences for CSCL. The third section is discussing about discourse, a major issue in both the polyphonic theory and in learning. The polyphony theory and its particularization in CSCL chats will be the subject of section four. The last section before conclusions will present also a system that is implementing the theory.

COMPUTER SUPPORTED COLLABORATIVE LEARNING THROUGH CHAT CONFERENCING

Hybrid Learning combines classroom learning with online learning. Usually, online learning is based on the idea of computer support for an individual style of learning. The student may get documents and advice via the computer. He may also be examined with, for example, online multiple answers tests, and a scheduling of the lessons he has to learn may be provided and even personalized by the computer (see, for example, Trausan-Matu & all, 2002).

In online learning, collaborative instruments are also provided, but usually are seen as auxiliary. The most popular tools are probably the email and the discussion forums. These collaboration facilities not only allow interactions among students and between students and professors, but they also extend the individual style of learning toward a social one, in which communities of students may discuss about, for example, some topics to be learned or they may jointly solve some problems. However, a disadvantage of discussion forums is their asynchronicity, which may introduce delays in interactions due, for example, to the temporarily absence of an addressee.

Another very popular collaboration media are instant messengers (chat). Their synchronous feature encourages students' involvement, inducing even a kind of a rhythm in the interactions. Nevertheless, one big problem in using instance messengers for chat conferences with several participants is that, in the absence of nonverbal cues like gazing, the addressee of some utterances might be hard to determine if, for example, several participants put a question in a short interval of time.

A solution to the addressee problem in chats is the provision of a way in the messenger system for explicitly specifying the previous utterance (by clicking on it) which is the destination of an utterance, if needed. Such a referencing facility is provided in the ConcertChat chat system (Holmer, Kienle & Wessner, 2006; see also http://www.ipsi.fraunhofer.de/concert/index_en.shtml?projects/chat), which was used in a Hybrid Learning course on Human-Computer Interaction at Politehnica University of Bucharest. The students were encouraged to use the referencing facility as much as they consider. In figure 1, showing an excerpt of a chat, the explicit students' references are

indicated in the second column and, for visualizing them, curly lines were drawn between the source and destination of a reference.

The usage of the explicit referencing facility of ConcertChat, in addition to solving the addressee problem, introduces a new opportunity, which is not encountered in face-to-face conferences: Having the possibility of explicitly linking utterances, multiple discussion threads may occur simultaneously, without the problem of unintelligibility due to the superimposing of the sounds of participants' voices. This phenomenon has been detected in almost all the CSCL chats we have analyzed. For example, in the chat excerpt from figure 1, several threads may be identified, from which the longest two are represented by the linked curly lines.

Nr	Ref	Time	User	Text
17		10.26.25	tim	You discussed about a topic separation
18	15	10.26.37	adrian	First of all, the reply method is cumbersome
19	17	10.26.50	john	yes.. because we did not like the way the topics were presented in concert chat
20	18	10.26.56	john	yes !!
21	20	10.27.04	john	i hate double-clicking!
22	20	10.27.18	tim	and how can we find topics ?
23	18	10.27.26	adrian	What bothers me is the linear presentation of the discussin
24	23	10.27.43	john	Yep
25	18	10.27.46	adrian	and double-clicking too
26		10.27.54	tim	You mean u want something like a chat forum ? :D
27	24	10.27.58	john	and the reply-to facility is supposed to help you
28	18	10.28.15	adrian	i'd like a tree presentation more
29	18	10.28.38	adrian	or maybe multiple chat columns, for each chat sub-thread
30	27	10.28.58	john	but it is really difficult to use in real-time, because there are so many topics discussed which intertwine each other
31	28	10.29.18	john	i subscribe to a tree-like presentation form
32	P 30	10.29.20	adrian	yes, that's why a clear separation of topics is needed
33	31	10.29.47	adrian	this is easy to implement, no problem here :)
34	30	10.29.49	tim	You need also a clever visual representation
35	30	10.30.05	tim	you'll need also a clever visual interface
36		10.30.22	tim	Who decides the topics ?
37	33	10.30.33	john	i suppose you are refering to the visual representation, right ?
38	37	10.30.45	john	What i would like is a clever way to separate the topics :)
39	38	10.30.59	john	not just doing ot myself, manually
40	37	10.31.00	adrian	Yeah
41	39	10.31.44	adrian	When you start a new thread (a new message, non-related to other message), the app can assume a new topic
42	39	10.31.46	john	i would like the application to be able to detect w topic change all by itself
43	42	10.32.01	tim	That right

Figure 1 Explicit and implicit threads of discussion

In addition to the explicit links, a second type of threading, starting from implicit links, is present in any linguistic artefact, including, of course, chat conversations. For example, in figure 1 are emphasized two such threads of implicit links generated by the repetition of the nouns "presentation" and "topic". In any discourse there are also implicit links generated by co-references and lexical chains (Manning & Schutze, 1999). Explicit and implicit links are the basis of the discourse formation and, meanwhile, the starting point in our polyphonic methodology.

In addition to the fact that there are several threads in parallel, even the same participant may participate to more than one discussion threads. For example, John, at utterance number 19, approves and elaborates Tim's utterance number 17. Immediately, at utterance 20, he approves Adrian's utterance 18. This phenomenon proves that there is not a situation in which several groups of participants communicate using independent threads. A normal consequence of the co-presence of multiple threads of discussions is

their inter-influences. For example, the two explicit link threads from figure 1 are obviously interacting between utterance 34 (of Tim) and 30 (of John), The same interaction occurs at utterances 37 and 38. In figure 2, these interactions are represented with thick arrows.
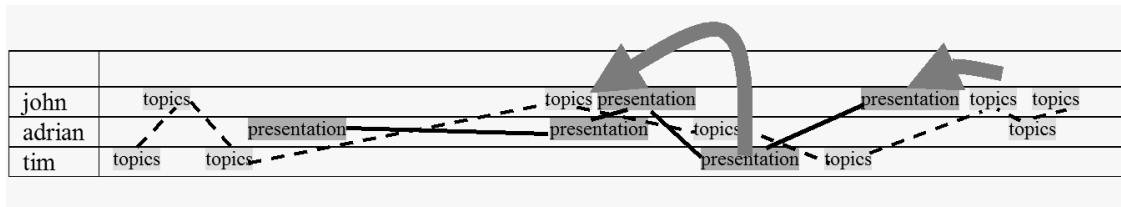

Figure 2. Interactions among threads

The interactions tend many times to exhibit an inter-animation phenomenon, similar to the polyphonic music, where voices activate and enable each other. Each of the participants introduces new themes in the discourse, or they iterate an already uttered theme. For example, in figure 1, several themes may be identified: "double-clicking", the "topics" in a collaborative chat, "reply method" and ways of "presentation". Moreover, when a CSCL chat is successful, the result is the accomplishment of a coherent discursive structure. For example, when the chat was performed for solving a problem, the collaborative achievement of a solution is characterized by an elaborated collaborative discourse. If the students were supposed to discuss or to debate a topic together, a sign of their success is also the achievement of a discourse.

In order to facilitate and analyze collaborative learning, threads of discussion and interactions that weave into a coherent discourse should be identified. Moreover, different types of interactions should be discriminated and, if possible, inter-animation patterns (Trausan-Matu & all, 2007b) have to be identified. A well-suited theory for accomplishing all these desiderata is Bakhtin's dialogism and polyphony (1973). Its usage for the analysis of CSCL chats will be discussed in a further section of this chapter. In order to prepare this discussion, the next section discusses discourse, a concept that includes the threads introduced above. Implementation approaches for identifying discourse in texts will be also analyzed. A dialogistic approach on discourse, that apply to written texts, to web, to chats, to individual learning or to professor lectures will be proposed.

Discourse

In the socio-cultural paradigm (stating that learning is achieved socially), which is now gaining ground in the face of the cognitive one (focusing on the knowledge in individuals' minds), the learning goal of achieving knowledge is directed more in the direction of social interaction and less toward an individual knowledge acquisition view. In this context, negotiation and discourse have a crucial role, as Deborah Hicks emphasizes: "Learning occurs as the co-construction (or reconstruction) of social meanings from within the parameters of emergent, socially negotiated, and discursive activity" (Hicks, 1996). Moreover, Sfard sees discourse as the major factor in learning: "rather than speaking about 'acquisition of knowledge,' many people prefer to view learning as *becoming a participant in a certain discourse*" (Sfard, 2000). Therefore, discourse should be a central issue in a theory about learning.

Discourse offers coherence to any natural language communication, from written text to speech. For analyzing chat and classroom conversations in Hybrid Learning and CSCL it is extremely important to identify and analyze discourse, in order to assess the effective learning situations. Computerized tools should be developed for supporting these goals.

From a linguistics point of view, discourse analysis is an "analysis of texts beyond and 'above' the sentence – the attempt to find linguistic regularities in discourse…its main concepts are cohesion – the features that bind sentences to each other grammatically and lexically – and coherence – which is the notional and logical unity of a text" (Newmark, 1988: 54). Salkie (1995: ix) says: "text or a discourse is a stretch of language that may be longer than one sentence. Text and discourse analysis is about how sentences combine to form texts by means of cohesiveness and coherence".

Discourse in computational linguistics

In computational linguistics there are several theories on discourse that follow the widely used computational idea of identifying structures in the form of networks consisting of nodes and relations among them. Probably the most known theories belong to Mann and Thompson (Rhetorical Structure Theory, or RST, 1987), Jerry Hobbs (Hobbs 1985), and Barbara Grosz & all (1995). RST identifies hierarchical rhetorical structures build using a limited set of rhetorical schemas (patterns) like antithesis, elaboration etc. Each schema has one nucleus and several satellites. Jerry Hobbs' theory is based on semantic coherence relations and interpretation as abduction inferences in formal logic (Hobbs 1985).

All these theories are referring mainly to discourse in texts and not to conversations. They consider that a discourse may be divided into several segments. Among discourse segments there may be different relationships, e.g. embedding (Grosz & all, 1995) or other types of relations. As Grosz states, discourse may be segmented in sequences of utterances. However, "discourses are more than mere sequences of utterances. For a sequence of utterances to be a discourse, it must exhibit coherence. Each discourse segment exhibits both *local coherence* – i.e. coherence among the utterances in that segment - and *global coherence* – i.e. coherence with other segments in the discourse." (Grosz & all, 1995).

Coherence is obtained, in Grosz's theory, at both local and global levels, by two aspects: intentional and attentional state, that, together with the linguistic structure of utterance sequence form a tripartite organization. There is an intentional structure in each discourse, assuring that discourse is rational. This structure is built from intentions (purposes) and, sometimes, beliefs of the author of the discourse (or of each participant in a conversation) and relations among them (Grosz & all, 1995).

Each participant, at any discourse point, has a focus of attention. "Changes in attentional state depend on the intentional structure and on properties of the utterances in the linguistic structure" (Grosz & all, 1995). The centering theory is trying to explain how local coherence is obtained. Each utterance has a center, which is an entity (for example, a noun phrase) used to link that utterance to other utterances in a discourse segment. Grosz & all introduce the notion of the set of forward-looking centers and of the (single) backward-looking center for each utterance.

Grosz & all identify three types of transition relations across utterances: center continuation, center retention and center shifting. These relations follow rules

(constraints) among utterances centers, like: "no element in an utterance can be realized as a pronoun unless the backward-looking center of the utterance is realized as a pronoun also" or "sequences of continuation are preferred over sequences of retaining sequences of retaining are to be preferred over sequences of shifting" (Grosz & all, 1995).

Probably the most important lack of such theories is their focus on the individual, on its intentions and the consideration of context as a list of entities. This is, we think, very well illustrated by rhetoric and even by Austin and Searle speech act theory (Jurafsky & Martin, 2000), that pays a central attention to the success of communication utterances but, as Duranti remarks, their theory is based on individual minds, is not considering collaboration (Duranti, 1997).

Computational linguistics has as the most ambitious goal the developing of computer programs for text understanding and is for some researchers a possible way to follow. However, there are very serious arguments against the feasibility of such an approach (Winograd, 1987; Winograd & Flores, 1986). Another perspective is the dialogism of Mikhail Bakhtin (1973, 1981), discussed in the following section.

Dialogic discourse

Mikhail Mikhailovici Bakhtin was a Russian philosopher, linguist and philologist that replaced the monologic Descartes-like way of thinking with a dialogic, inter-animation paradigm. He raises the idea of dialog to a fundamental philosophical category: "… *Any true understanding is dialogic in nature*" (Voloshinov 1973, p. 102). This is in consonance with Lotman's conception of text as a „thinking device" (Wertsch 1981, p. 74), determining that: "The semantic structure of an internally persuasive discourse is not *finite*, it is *open*; in each of the new contexts that dialogize it, this discourse is able to reveal ever new *ways to mean*" (Bakhtin 1981, pp.345-346).

Bakhtin continues and extends Vygotsky's ideas (Wertsch 1991; Duranti 1997; Koschmann 1999) and dialogism may be even seen as a new philosophical paradigm that has a more large extent than dialectics (Markova, 2003). He extended Vygotsky's ideas in the sense of considering the role of discourse and language, with emphasis on speech and dialog. His basic ideas are the dialogism, the universality of the presence of multiple voices in any text, the speech genres, the polyphonic character of some texts and inter-animation.

Vygotsky has a permanently increasing influence on learning theories. He stated that learning is a social process, mediated by specific tools, in which symbols and especially human language plays a central role. However, he didn't investigate in much detail how the language and discourse is actually used in collaborative activities. It is the merit of Bakhtin to propose a sound theory of how meaning is socially constructed.

A very important idea brought by Bakhtin, related to the above communitarian characteristics of utterances, is that of speech genres, that determines "definite and relatively stable typical *forms of construction of the whole*" (Bakhtin, 1986, p. 78). Speech genres may be seen also as an additional form of coherence besides intentional and attentional states identified by computational linguistics theories like that of Grosz and al. (1986, 1995). To acquire knowledge may be seen as the ability of building a discourse in a given speech genre (e.g. mathematics, see Livingstone 1986): "to learn is to become a skilled member of communities of practice …. and to become competent at using their …. speech genres" (Stahl, 2006).

However, communities of voices, in parallel to the unity trend, have an additional differential, *unmerged*, character: "The *intersection, consonance, or interference of speeches in the overt dialog with the speeches in the heroes' interior dialogs* are everywhere present. *The specific totality of ideas, thoughts and words* is everywhere *passed through several unmerged voices, taking on a different sound in each*" (Bakhtin, 1973, p. 226). This dual nature of community and individuality of voices is expressed by Bakhtin also by the concept of *polyphony*, that he considers the invention and one of the main merits of Dostoevsky novels (Bakhtin, 1973). The relation of discourse and communities to music was remarked also by Tannen: "Dialogue combine with repetition to create rhythm. Dialogue is liminal between repetitions and images: like repetition is strongly sonorous" (Tannen, 1989, p. 29)

Utterances at Bakhtin have a wide extent, "from a short (single-word) rejoinder in everyday dialogue to the large novel or scientific treatise" (Bakhtin, 1986, p. 71). Even if they include not only spoken language, Wertsch remarked that "an utterance can exist only by being produced by a voice" (Wertsch, 1991, p. 51). Moreover, one of the main ideas of Bakhtin is that each utterance is, in fact, filled with a multitude of voices, this idea being strongly related to communities: "The very being of man (both external and internal) is the *deepest communion. To be means to communicate*.... To be means to be for *another*, and through the other, for oneself" (Bakhtin, 1984). Even inner speech is, as Vygotsky also noted, a "unique form of collaboration with oneself" (quoted in Emerson, 1986, p. 33).

THE POLYPHONIC MODEL OF COMPUTER SUPPORTED COLLABORATIVE LEARNING

Polyphony in music

Polyphony is a technique used especially in classical music (mastered, for example, by Johann Sebastian Bach in his musical fugues, but which may appear also in improvisations, for example in jazz or latino music) involving several independent participants (or "*voices*") singing simultaneously. The goal is to obtain a *coherent* framework (a nice sounding musical piece) starting from a given *theme*, even if transient deliberated *dissonances* are introduced. In order to achieve coherence, several *harmony* assuring rules should be respected, the so-called *counterpoint* rules (how notes may be used "point counter point" in the joint play of several participants):

"When there is more than one independent melodic line happening at the same time in a piece of music, we say that the music is contrapuntal. The independent melodic lines are called counterpoint. The music that is made up of counterpoint can also be called polyphony, or one can say that the music is polyphonic or speak of the polyphonic texture of the music." (Polyphony, 2005).

In polyphony, the leading theme is the seed of melody that is the basis for further developments in the musical piece. A melody lasts in time and, therefore, is *longitudinal*, being characterized by duration and a sequence of notes.

When there are several voices playing in the same time, other rules apply than in the longitudinal case. These are the *transversal* rules of harmony, for example, what chords

sound consonant. In polyphony, the situation is more complex because each of the voices play in paralel the same theme but they also should bring some *variations* in order to be creative, to avoid monotony. Sometimes short *dissonances* are introduced, creating a conflinct to be solved, in a kind of an inter-animation process.

The above mentioned phenomena of variation and transient dissonance bring a new, orthogonal dimension on the longitudinal-transversal axis. They are a manifestation of the *unity-difference* distinction. It may take the form of a competition similar to the one emphasized by Bakhtin in discourse in the novels. He compared the unity-difference competition to that between *centripetal* forces and *centrifugal* ones (Bakhtin, 1981). The most important fact is that this phenomena generate and maintain *inter-animation* among the participants in the chat. We can conclude that a desideratum of a successful chat for CSCL should include an important degree of inter-animation and, meanwhile, all along the chat, these developments, both longitudinal, melodic rules and transversal, harmonical rules should be respected.

A polyphonic perspective of Hybrid Learning

From the polyphonic perspective, we understand by a "voice" not the acoustical, physical, vocal expression of a given participant in a dialogue but, rather, a distinct position, an utterance, an event or a recurrent series of events of emitting utterances that are heard, reminded, discussed and have influence on the utterances emitted of the other voices. This perspective is a well-suited model for Hybrid Learning because it naturally allows the consideration of blending the voices of the professors in classroom teaching and the voices of the participants in dialogues, including chat collaborative activities.

In addition to the above group perspective, in our opinion, polyphony is implied also beyond group interaction. In individual learning (and, in general, in any knowledge building process) multiple voices also are implied, being, somehow, a form of internalized collaboration, as follows: Reading texts and trying to understand them implies the inner voice of the reader in a joint process with the voice of the author. There is a dialog in which the reader interprets what he reads, put questions, and try to integrate the new data in what he already knows. Solving problems is also a dialog, between the voice of the author or of the professor, who ask for the solution and the solver. Even writing is dialogic, being a classical example used by Bakhtin to illustrate how the voice of the author is melded with the voices of the potentials readers Moreover, even the activity of teaching something (even if there is no feedback from the students, in Bakhtin's terminology, even their voice is not expressed but only potentially intuited by the teacher) may determine a collaboration effect (for example, from my personal experience, I remarked that lecturing enhance knowledge building even if there is no actual dialog with the students). From another point of view, we must extend the concept of voice to the present persons, even if they do not say something.

Another extension of the polyphonic model is to class-based learning and, if we add also CSCL, to Hybrid Learning. This perspective is supported also by Bakhtin's view on utterances as encompassing more than a spoken intervention, as we discussed in the section on discourse. Therefore, we can consider *hybrid learning as a polyphony of contributions from several participants, professors and students and using different kinds of utterances, in an extended sense.*

Polyphony in chats

The basic assumption of the usage of the polyphonic model in analyzing CSCL chats is that we can use the musical analogy of polyphony for evaluating the degree of inter-animation and the contribution of every student. By analyzing the themes of a conversation, the inter-animation patterns (Trausan-Matu & all, 2007b) and the participation of each student to this framework, we can assess the participation and contribution of each of them. Moreover, from the analysis results, feedback may be provided to the participants and suggestions may be driven for the most suitable kinds of chat sessions. In addition, for the designers of collaborative chat environments may be suggested new support tools.

Some obvious prerequisites of Computer Supported Collaborative Learning are the need that each participant involves himself/herself in the collaboration and that s/he inter-animates with the other participants in order to achieve the task they have to do. CSCL may be used according to different scenarios like problem solving (e.g. mathematics in VMT), experimenting for understanding, role-based disputes (e.g. at Politehnica University), collaborative design, etc. In all these cases, a successful learning process has as manifestation the development of a coherent and elaborated discourse (solution to a problem, explanations, justifications or designs) consisting of collaborative utterances, repetitions, difference making and other inter-animation patterns (Trausan-Matu & all, 2007b). In the following sub-sections we will illustrate with examples such classes of unity-difference along longitudinal/transversal directions polyphonic inter-animation situations. We will present several examples of good collaboration in CSCL chats and their polyphonic interpretation. Examples are taken from real chat sessions of the VMT project at Drexel and K-teams and LTfLL projects at PUB.

Collaborative utterances

Several types of discourse may occur in CSCL chats. For example, in one of the VMT chat excerpts, from 221 to 231 there is a negotiating discourse on what problem to choose to be solved:

> **221 mathwhiz344: i can't think of any, but number 6 looks interesting**
> **222 dragon: number 7**
> **223 mathwhiz344: so which one should we do?**
> **224 dragon: I don't know, anything that interests us I guess**
> 225 gdog: #6 is interesting to me
> **226 dragon: problem is**
> **227 dragon: there really isn't an answer to number 6 though**
> 228 weisbari: joins the room
> **229 mathwhiz344: yeha**
> 230 gdog: that's why it's interesting
> **231 dragon: it depends who is giving the problem**

Such types of negotiating discourses appear in many collaborative situations (Stahl, 2006). From the polyphonic perspective, they may be considered as longitudinal (threads) along a transversal disaccord.

Another kind of discourse is the exploratory one. An excellent example of such a discourse is illustrated below by the co-building of knowledge about one problem they have to solve: how is changed the problem of finding the shortest path between two

points on a grid if the grid is no more planar but curved. In this discourse, practically only dragon and mathwiz344 are effectively contributing (the messages preceded by "@" are references to prior utterances, provided by the ConcertChat system):

> **232 mathwhiz344: the grid probably extends for ever,**
> **233 mathwhiz344: but if it's a curved space, it might meet**
> 234 gdog: assuming if it doesn't..........
> **235 dragon: that would make things too complicated**
> **236 dragon: I guess**
> 237 gdog: y?
> **238 dragon: but it could work maybe**
> **239 mathwhiz344: what if we asssumed the grid is a universe...**
> **240 mathwhiz344: i guess your right**
> 241 gdog: ok
> 242 gdog: i understand
> **243 dragon: well, first of all, the paper would crumple (if it were real) to form a sphere**
>   **@: Message 237:**
> **244 mathwhiz344: why a sphere?**
> 245 gdog: ?
> **246 dragon: I mean, if it were "curved" as you said before**
>   **@: Message 244:**
> **247 dragon: like**
> **248 mathwhiz344: oh**
> **249 dragon: it would curve to itself**
> **250 mathwhiz344: yeah**
> 251 dragon: and then it would have to get smaller in some areas to fit
> **252 dragon: nvm**
> **253 dragon:**

It is extremely important that the utterances of the two main participants almost seem to be generated by a single person, we could say, in Bakhtin's terminology, that they inter-penetrate:

> **the grid probably extends for ever, but if it's a curved space, it might meet**
> **what if we asssumed the grid is a universe...**
> **well, first of all, the paper would crumple (if it were real) to form a sphere**
> **why a sphere?**
> **I mean, if it were "curved" as you said before**
> **it would curve to itself**
> **and then it would have to get smaller in some areas to fit**

This kind of unity phenomenon is extremely important and relevant because it reflects ideal moments of collaboration, which were discussed in large also in Sacks (Sacks, 1992, pp.144-5) and in Lerner (Lerner, 1993). For example, Sacks analyzes in several instances the following fragment of conversation in which the participants emit collaborative utterances, which produce a sole sentence:

> *"Joe :*   (cough) We were in an automobile discussion,
> *Henry :*   discussing the psychological motives for
> *Mel :*   drag racing on the streets"
>
>   (Sacks, 1992, pp.144-5)

Another example of collaborative utterances is:

117 ModeratorSf, 20:33 (19.05): could you guys tell templar what's going on?
118 mathpudding, 20:35 (19.05): we're experimenting with circles
119 mathman, 20:35 (19.05): and finding as many possible relations as we can

The collaborative utterances are rather rare in conversations. However, collaboration occurs very frequently under other dialogical longitudinal inter-animation schemes, like question-answering:

68 mathisfun, 20:26 (19.05): see angle alpha?
69 bob123, 20:26 (19.05): yes
70 bob123, 20:26 (19.05): what about it?
71 mathisfun, 20:26 (19.05): is that 60 degrees?
72 bob123, 20:26 (19.05): yes
73 mathisfun, 20:27 (19.05): can u use the degree, 2 length to find the last length of a triangle?
74 bob123, 20:27 (19.05): i don't get what you're saying
75 mathisfun, 20:27 (19.05): the two arrow pointed lengths and the angle can find the length A
76 bob123, 20:28 (19.05): by what?
77 mathisfun, 20:28 (19.05): the two sides and the degree
78 bob123, 20:29 (19.05): and how do you use the two sides and the degree to find the third side?
79 mathisfun, 20:29 (19.05): one moment
80 mathisfun, 20:29 (19.05): There is a fomula I think

Another example is:

83 EatUrSqRts, 20:31 (19.05): k, so add the 1/2 infinite series
84 EatUrSqRts, 20:31 (19.05): ull see it approaches 1/1 correct?
85 Jason, 20:31 (19.05): ummm lemme see
86 Jason, 20:32 (19.05): yes
87 EatUrSqRts, 20:32 (19.05): and 1/3 approaches 1/2 right?
88 Jason, 20:32 (19.05): sure
89 EatUrSqRts, 20:33 (19.05): so lets se one person
90 EatUrSqRts, 20:33 (19.05): 10/11 divide by 10 is...
91 Jason, 20:33 (19.05): 1/11
92 EatUrSqRts, 20:33 (19.05): good, so wut infinite series approaches 1/11
93 Jason, 20:33 (19.05): 1/12?
94 EatUrSqRts, 20:34 (19.05): good!
95 Jason, 20:34 (19.05): :-)
…………………..
133 EatUrSqRts, 20:47 (19.05): so, 10/12 is eaten, how much is left?
134 Jason, 20:47 (19.05): 2/12
135 FooFoo, 23:48 (19.05): 1/6
…………………..
156 EatUrSqRts, 20:54 (19.05): (collumns+1)(rows)(2)
157 EatUrSqRts, 20:55 (19.05): anyone disagree?
158 Jason, 20:55 (19.05): check it
159 EatUrSqRts, 20:56 (19.05): 56?
160 Jason, 20:56 (19.05): that can't be the area
161 EatUrSqRts, 20:56 (19.05): no, the # of short paths

Discourse in the previous examples, exhibiting moments of collaboration (Stahl, 2006), may be resembled with a collective poetry, where participants in a chat seem to enter in the rhythm of a poem. Something similar was reported also by Stahl:

"Heidegger's favorite art form is poetry. Poetry makes language visible (see Heidegger …). Poetry is a source for the creation of new expressions and new forms of speech. Poetry also opens up worlds, and it can name the elements that it brings together in those worlds. For Heidegger, language speaks (Sprache spricht). It is not so much that people use words to express

their ideas, but that language speaks through us. (…) What took place there happened largely through the power of language, the mechanisms of discourse. Utterances built on each other. Words gathered richness of meaning through repetitive usage. The discourse itself provided an opportunity for all this to happen." (Stahl, 2006, p.412)

It is clear that this phenomenon in which utterances "built on each other" is extremely similar to what happens when entering a state of flow (Czikszentmihaly, 1990). Music, poetry, collaboration are probably related to this special state. In fact, polyphony may appear spontaneously in jazz music, which may be considered as entering in a group state of flow and a prototype for a successful collaboration.

Another interesting observation in the second chat excerpt from this section (utterances 232-253) is that, in addition, it seems that there are two threads of discussion between the same two participants and, something similar to a contrapunctus in a Bach fugue. In the same time with the discourse discussed above (232, 233, 239, 243, 246, 249, 251), similar to a exploratory narrative, the following discourse appear (thread of utterances 232, 233, 235, 236, 238, 240):

> **the grid probably extends for ever, that would make things too complicated I guess but it could work maybe i guess your right**

Such a dialogue with multiple threads is specific to chats (see also the threads from figure 1). In real, face to face discussions of only two or three persons, multithreading is much more difficult to happen. In fact, this possibility of multithreaded discourse must be encouraged, humans being able to handle them. Moreover, it is possible that we maybe even need them. The examples of musical fugues, of polyphony, of movies or novels (a detailed discussion about poliphony in novels can be found in Bakhtin's writings (1973, 1981) are, in our oppinion very good illustrations of multithreaded discourse.

A third kind of discourse is determined by estrickmcnizzle, that seems to be bored and feels the need to introduce a difference, to interrupt the previous discourse. As a consequence, probably also because the other two participants feel the need to end the discourse (they could ignore estrickmcnizzle intervention), an ending discourse sequence is generated and then a fourth, negociation discourse is started:

> 254 estrickmcnizzle: im drinking 7 up
> **255 dragon: this is getting way too complicated, xp**
> 256 gdog: dragons right @: Message 249:
> 257 gdog: we should probably solve another problem
> **258 dragon: so, do you guys think any other questions would be good to answer?**
> **259 mathwhiz344: yeah:0**
> 260 gdog: and drop that question
> **261 dragon: I like 7**
> **262 mathwhiz344: 7's good**
> 263 gdog: ok, we can try 7
> 264 estrickmcnizzle: so is 7 up
> **265 dragon: alright**
> **266 dragon: lol**
> 267 gdog: lol
> **268 mathwhiz344: :)**

As conclusion, different types of discourse may be encountered, some of them being exemplified in the above examples: openings, negotiation, exploration, solution building, conversation ending, etc. (see also Sacks, 1992). From another perspective, discourses in

chats may be classified as social (openings and greetings) and mathematical (problem solving).

Repetitions

We consider that another extremely important phenomenon, related to polyphony and reflecting collaboration is repetition. For example, „two ways" is repeated several times in the following VMT chat excerpt:

> 160 mathisfun, 20:26 (12.05): k so there are two ways right?
> 161 bob123, 20:27 (12.05): yeah
> 162 bob123, 20:27 (12.05): 2c1=2
> 163 Marisol, 20:27 (12.05): yes, I agree there are only two ways
> 164 mathisfun, 20:27 (12.05): then there is a one by two
> 165 qwer, 20:29 (12.05): only two ways? @: Message 158: To whole message
> 166 mathisfun, 20:28 (12.05): is the one by two going to be 4 ways?

Zemel remarked that, in face-to-face collaborative problem solving, students tend also to unconsciously imitate each other's gestures, or to move together like in choreography (Zemel, 2005). We consider such phenomena as manifestations of the appearance of a state of group flow, of a collaborative moment, of a successful discourse.

> 69 ModeratorSf, 20:14 (19.05): you can continue the problems from last time or we can try another, what you say?
> 70 mathpudding, 20:16 (19.05): try another
> 71 TinyFryhiii12, 20:15 (19.05): another
> 72 mathman, 20:16 (19.05): another we came to a solution for the one last time

The relation of repetitions to music (and poetry) are remarked also by Tannen (Tannen, 1989). She considered that repetitions are sound patterns, that are used together with sense patterns as narrative, ellipsis, tropes, indirection, imagery as involvement strategies (Tannen, 1989, p.17).

An interesting repetition situation appears in another VMT chat, where an ad-hoc phrase (30/60/90) is repeated several times (including variations):

> ping ponger 805 (8:24:54 PM): its a **30/60/90** triangle
> SuperEvo88 (8:26:08 PM): if its equilateral its it a **45/45/90** triangle?
> AvrilLR (8:27:00 PM): equilateral is **60/60/60** triangle
> AvrilLR (8:27:15 PM): not **30/60/90**
> ping ponger 805 (8:27:17 PM): anyone remember formula for **30/60/90** triangle?
> AvrilLR (8:28:33 PM): so it can't be **30/60/90**
> AvrilLR (8:28:39 PM): it's not a **30/60/90** triangle
> SuperEvo88 (8:29:04 PM): is there a formula for a **60/60/60**?
> AvrilLR (8:37:52 PM): okay it's TWO **30/60/90** triangles
> AvrilLR (9:26:34 PM): like the ratios of the sides of a **30/60/90** are 1/2/sqrt2 or something
> SuperEvo88 (9:30:20 PM): we detremined its a **30/60/90** triangle

Difference making

Difference making has a crucial role in collaborative chats. The possibility of contemplating from a critical position the others' ideas and entering into a polyphonic framework enhances problem solving and enables learning through a trial-error process. Such processes appear also in individual problem solving but the presence of multiple participants enhance both the possibility of developing multiple threads and, meanwhile,

of difference identification. The inter-animation of the multiple perspectives of the participants, the opposition as result of contemplation and the presence of a third opinion in case of conflict and sometimes the synthesis it brings are a better asset to success than a multi-voiced discourse performed by an individual, that is inherently much less critique.

For example, in the following excerpt of the collaborative solving of the "ducks problem" at Politehnica University, after a negotiation ended with an agreement, p4nzer, petry_g and tricavl enter into a dialog of longitudinal inferences (emphasized as bold) and transversal (italic) differences:

p4nzer: I'm thinking that in the shortest move sequence, "a" must ONLY move to the right and "b" ONLY to the left
p4nzer: do you agree?
tricavl: yes... you're right
petry_g: agree
tricavl: so we start with aaa_bbb
p4nzer: yes... the first move is simple...
p4nzer: it doesn't matter if we move an "a" or a "b" in the empty space.
tricavl: ok
tricavl: so aaa_bbb become aaab_bb
p4nzer: one moment thou... from what I do understand, A can only jump over B and vice-versa
tricavl: let's see!
p4nzer: so... let's say we move an a
p4nzer: we now have aa_Abbb
petry_g: ok...i think i begin to understand :))
tricavl: now what? b over a?
tricavl: aa_Babb?
p4nzer: well... if we were to move the "a" we would get stuck
p4nzer: no, that's not a valid move
p4nzer: aaba_bb is. do you understand why?
tricavl: ohh... so you moved the space twice to the right?
p4nzer: no
p4nzer: only one move
p4nzer: "b" over "a"
p4nzer: aa_aBbb -> aaBa_bb
p4nzer: get it?
tricavl: ohh... so "b" change place with the space?
p4nzer: exactly: "jumped over a into an empty space"
petry_g: yes. alex is right.
tricavl: ok. next step...
petry_g: now we can either move the "b" one space to the left or the "a" one space to the right
p4nzer: correct, no jumping moves here!
tricavl: it's the same thing
tricavl: let's move the "a"
p4nzer: aabA_bb -> aab_Abb
p4nzer: hmm... this does not look good
p4nzer: I get the feeling that if we get the sequence "aabb" we're stuck
tricavl: why? i think the algorithm here is to move the space to the righ and came back with a "b"
petry_g: "sequence "aabb" we're stuck.."..me too
p4nzer: yes, and everything we can do from here, we get an "aabb"
p4nzer: so the move aabA_bb -> aab_Abb is wrong
tricavl: ok. i think we should continue with aab_Abb -> aabbA_b
tricavl: we are using the space to control our moves.
p4nzer: ok. if you think we're wrong, what do u have in mind?

Sometimes, the participants even explicitly states that they found a difference:

p4nzer: agree with me so far?
tricavl: yes, but i did the same thing

tricavl: the difference was the place of the space :).
petry_g: and the number of moves :)

Evidence that participants permanently keep a differential position, that they do not totally enter in an unity is also provided by the usage of personal pronouns. For example, in a corpus of chats recorded in May 2005, "I" was used 727 times and "we" only 472 times. 84 times was used "me" and only 34 times "us". However, alterity is very well represented by 947 uses of "you".

A TOOL FOR THE VISUALIZATION OF THE PARTICIPATION IN THE COLLABORATIVE LEARNING CHAT

One desideratum of a successful CSCL session is a coherent and elaborated discourse, in which participants inter-animate. Such a discourse, as we have discussed in the previous sections, may be modeled as a polyphonic weaving, manifesting longitudinal/transversal and unity/difference coherent interactions. Therefore, for assessing the quality of a collaborative learning session, it is extremely important to have tools that analyze this polyphonic framework of the discourse and that provide useful abstractions to both teachers and students. Moreover, supporting tools for collaborative learning should encourage polyphonic inter-animation.

A tool was developed for the detection and the visualization of threads and their inter-animations from a polyphonic perspective (Trausan-Matu & all, 2007a). First of all, the themes (the topics) of the chat are detected. For this aim, text mining techniques (Manning & Schutze, 1999) eliminate unrelevant words and group similar nouns using the lexical ontology WordNet (http://wordnet.princeton.edu). Secondly, the links among utterances in the chat are detected. If a chat environment like ConcertChat is used, the explicit links are obviously considered. For detecting implicit links, several techniques are used, like repetition of words or patterns.

Figure 3 is a snapshot of the graphical representation of the chats and of the influence of the participant voices (Trausan-Matu & all, 2007a). For each participant in the chat there is a separate horizontal line in the graphical representation. Each utterance is placed in the line corresponding to the issuer of that utterance, taking into account its positioning in the original chat file, using the timeline as an horizontal axis. Each utterance is represented as a rectangle aligned according to the issuer on the vertical axis and having a horizontal axis length that is proportional with the dimension of the utterance. The distance between two different utterances is proportional with the time passed between them. The relationships between utterances are represented with lines that connect these utterances. The lines have different colors, according to the type of reference (explicit or implicit - Trausan-Matu & all, 2007a).
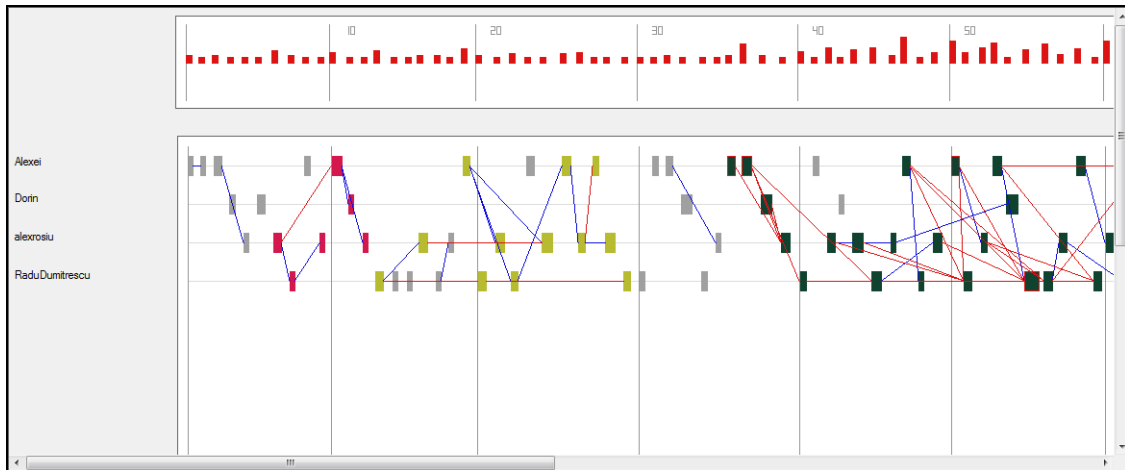
Figure 3. Visualization of a chat, emphasizing the discussion threads

The degree in which a participant involves himself/herself and the inter-animation may be determined either by the visualization tool (using a view at a compressed ratio) or by a quantitative analysis using social network analysis algorithms (Cristea & all, 2007). For example, in figure 4a, in the middle of the conversation there is a visible rather long segment where only adrian speaks and there is no dialog. In figure 4b, several participants (tutor, TBryant) have a clearly visible very reduced participation.
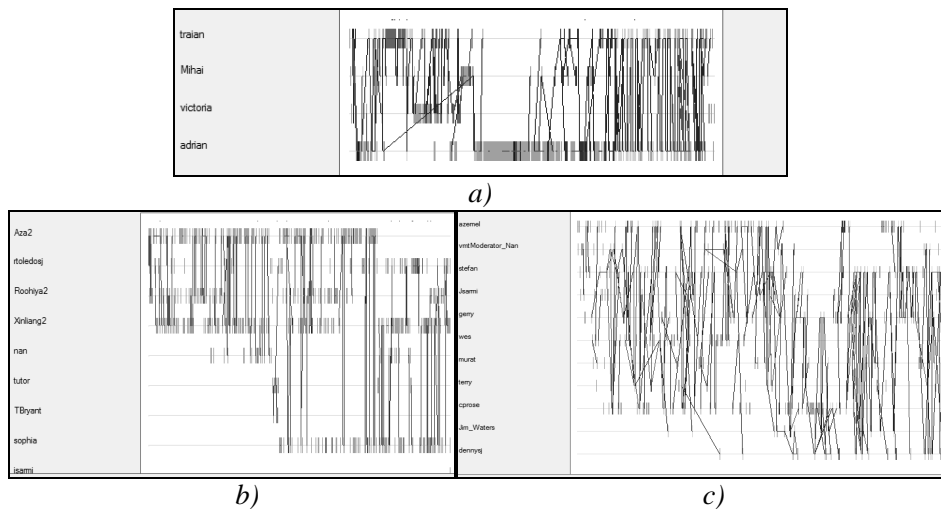

a)

b)   *c)*

Figure 4. Global view of a chat

In contrast, the conversation in figure 4c, displays a rather uniform distribution of utterances among participants.

At the top of the graphical representation of the conversation (see figure 3) there is a special area that represents the importance of each utterance as a rectangle, considered as a chat voice in the conversation. This importance is computed using some heuristics that consider the effects of the utterances on the rest of the conversation (Trausan-Matu & all, 2007a). Starting from the importance values, a graph that shows the contributions of every participant may be drawn (see figure 5). This graph contains on the horizontal axis

the utterances in the chat and on the vertical one the value attributed to each participant in the conversation, representing the sum of each user's contributions.
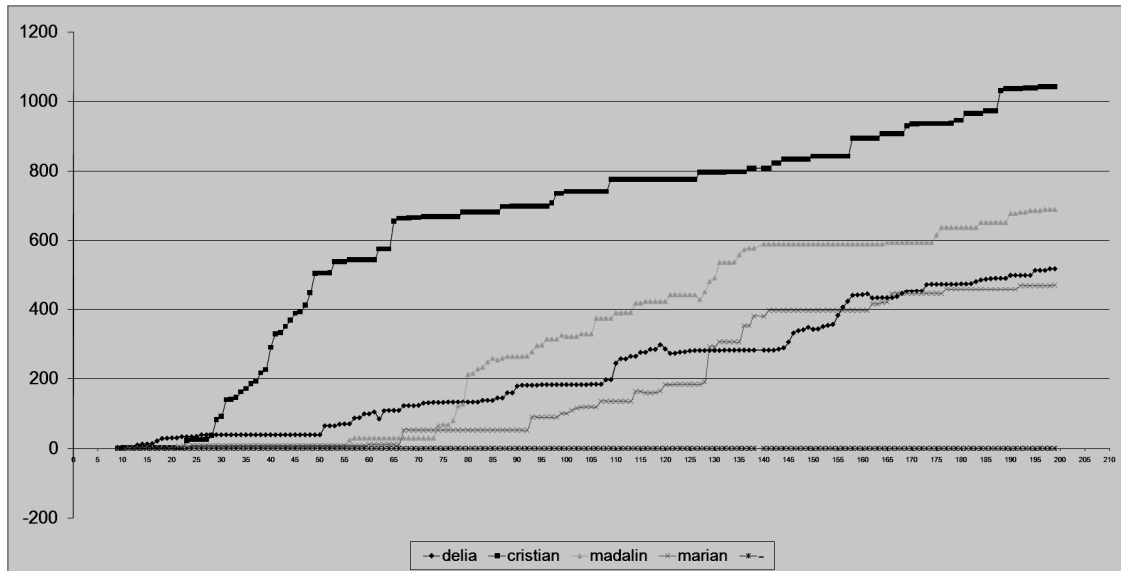

Figure 5. The variation of participants' contributions

CONCLUSIONS

Discourse in chats and in face to face conversations is characterized by an inter-animation of multiple voices along two dimensions, the sequential, longitudinal utterance threading and the transversal, differential one. These two dimensions correspond to a unity-difference (or centrifugal-centripetal, see Bakhtin, 1981) basic feature of polyphony. The unity directed dimension is achieved at diverse discourse levels by repetitions, collaborative utterances, socializing and negotiation discourse segments.

The second, differential dimension could be better understood if we consider discourse as an artifact that, taking into account that every participant in collaborative activities has a distinct personality, is a source of a critical, differential attitude. Even if individual discourse is multi-voiced, difference and critique are possible especially in collaborative contexts.

In each dialogue, similarly to polyphonic music, there are one or more themes, which are debated by the participant voices. Each theme is introduced by a voice and developed by it and/or the others. Several themes may be present in the same time in the dialogue, influencing each other.

According to Bakhtin's perspective, we may consider that the themes of a chat, during their development, are filled with the overtones of the voices (the contributions that are on a distinct position) of the participants. In addition to their sequential intertwining, voices interact transversally, they inter-animate according to several patterns, the themes weaving like in a music-like polyphony.

The polyphonic theory should be further elaborated. A three years European Union project (LTfLL - http://partners.ltfll-project.org/) has as one of its objectives to develop tools providing feedback to learners starting from analyzing the polyphonic structuring of

the chats they performed. One of its side effects will be also the development of the theory.

Another interesting future issue is the extension of the polyphonic theory to encompass Hybrid Learning in general and individual learning or class-based learning in particular.

REFERENCES

Bakhtin, M. (1973). *Problems of Dostoevsky's Poetics*, Ardis, (translated by R.W.Rotsel).

Bakhtin, M. (1981). *The dialogic imagination: four essays*. Austin, TX: University of Texas Press.

Bakhtin, M. (1984). Problems of Dostoevsky's Poetics. In *Theory and History of Literature Series* (translated by C. Emerson).

Bakhtin, M. (1986). *Speech genres and other late essays*. Austin, TX: University of Texas Press.

Cristea, V., Trausan-Matu, S., Posea, P., & Gartner, A. (2007). Towards an evaluation methodology for collaborative learning. In *Proceedings of CSCS16*, Bucharest (pp.161-168).

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper Collins.

Duranti, Al. (1997). *Linguistic anthropology*. Cambridge, UK: Cambridge University Press.

Emerson, C. (1986). The outer word and inner speech: Bakhtin, Vygotsky, and the internalization of language. In G. S. Morson (Ed.), *Bakhtin - Essays and Dialogues on His Work*. Chicago, IL: University of Chicago Press.

Grosz, B.J., Joshi, A.K., & Weinstein, S. (1995). Centering: A framework for modelling the local coherence of discourse. *Computational Linguistics, 21*(2), 203-225.

Hobbs, J.R. (1985). *On the coherence and structure of discourse.* Technical Report CSLI-85-37, Center for the Study of Language and Information, Stanford University.

Juravsky, D. & Martin, J. (2000). *Speech and language processing: An introduction to natural language processing, computational linguistics and speech recognition*. San Francisco, CA: Prentice Hall.

Koschmann, T. (1999). Toward a dialogic theory of learning: Bakhtin's contribution to understanding learning in settings of collaboration. In C. Hoadley & J. Roschelle (Eds.), *Proceedings of the Computer Support for Collaborative Learning 1999 Conference*. Philadelphia, PA: Laurence Erlbaum Associates.

Lerner, G. H. (1993). Collectivities in action: Establishing the relevance of conjoined participation in conversation. *Text*, 13(2), 213-245.

Livingstone, E. (1986). *The ethnomethodological foundation of mathematics*. London: Rutledge & Kegan Paul.

Mann W., C. & Thompson, S.A. (1987). *Rhetorical structure theory: A theory of text organization*. Technical Report ISI/RS-87-190, Information Sciences Institute, University of Southern California.

Manning, C., & Schutze, H. (1999). *Foundations of statistical natural language processing*. Cambridge, MA: MIT Press.

Markova, I. (2003). *Dialogicality and social representations: The dynamics of mind*. Cambridge, UK: Cambridge University Press.

Newmark, P. (1988). *A textbook of translation.* Hertfordshire, UK: Prentice Hall.

Polyphony. (2008). Retrieved December, 1, 2008 from http://cnx.rice.edu/content/m11634/latest/

Sacks, H. (1992). *Lectures on conversation*. Oxford, UK: Blackwell.

Schegloff, E. (1981). Discourse as an interactional achievement: Some uses of 'uh huh' and other things that come between sentences. In D. Tannen (Ed.), *Georgetown University Roundtable on Languages and Linguistics 1981; Analyzing Discourse: Text and Talk*. Washington D.C.: Georgetown University Press.

Sfard, A. (2000). On reform movement and the limits of mathematical discourse. *Mathematical Thinking and Learning*, 2(3), 157-189.

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.

Tannen, D. (1989). *Talking voices: repetition, dialogue, and imagery in conversational discourse*. Cambridge, UK: Cambridge University Press.

Trausan-Matu, S., Maraschi, D., & Cerri, S. (2002). Ontology-centered personalized presentation of knowledge extracted from the Web. In S. Cerri, G. Gouarderes (Eds.), *Intelligent Tutoring Systems 2002* (LNCS 2363, pp 259-269). New York: Springer.

Trausan-Matu, S., Stahl, G., & Sarmiento, J. (2006). Polyphonic support for collaborative learning. In Y.A. Dimitriadis et al. (Eds.), *CRIWG 2006 (LNCS 4154,* pp. 132 – 139*)*. New York: Springer.

Trausan-Matu, S., Rebedea, T., Dragan, A. & Alexandru, C. (2007a). Visualisation of learners' contributions in chat conversations. In J. Fong & P. Wang (Eds.), *Blended Learning* (pp. 215-224). Upper Saddle River, NJ: Prentice Hall.

Trausan-Matu, S., Stahl, G., & Sarmiento, J. (2007b). Supporting polyphonic collaborative learning. *E-service Journal*, *6*(1), 58-74.

Turing, A. M. (1950). Computing machinery and intelligence. *Mind*, 59, 433-460.

Voloshinov, (1973). *Marxism and the philosophy of language*. New York: Seminar Press.

Vygotsky, L. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Wertsch, J.V. (1991). *Voices of the mind*. Cambridge, MA: Harvard University Press.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition*. Norwood, NJ: Ablex.

Winograd, T. (1987). Thinking machines: Can there be? Are we? *Report No. STAN-CS-87-1161*, Stanford, California.

Zemel, A. (2005). Personal communication.

KEY TERMS & DEFINITIONS

Dialogism: A conception introduced by Mikhail Bakhtin, which considers that every human language-based artefact and activity is a dialog, including not only conversation but also written texts or even thinking.

Discourse: A human language coherent achievement starting from a theme, which is longitudinally developed in time.

Intelligent Tutoring Systems: Computer programs with artificial intelligence that can assist, as a human tutor, a student in learning. This kind of systems is based on the cognitive paradigm, and tries to build a model of the knowledge that a student have. Starting from this model and a model of the knowledge of a given domain (a knowledge base or an ontology), the system tells to the student what to do next for achieving learning.

Inter-animation: A phenomenon specific to polyphony or to groups of collaborating people in which several voices are entering in dialog and, due to unity-difference (centripetal-centrifugal) interactions, a theme is developed.

Polyphony: A joint achievement that involves several independent participants that are collaboratively developing a time-lasting coherent framework starting from a given theme, even if transient deliberated dissonances may appear. In order to achieve coherence, several harmony assuring rules should be respected.

Utterance: An intervention using human language. It may range "from a short (single-word) rejoinder in everyday dialogue to the large novel or scientific treatise" (Bakhtin 1986, p. 71).

Voice: A distinct position, an utterance, an event or a recurrent series of events of emitting utterances that are heard, reminded, discussed and have influence on the utterances emitted of the other voices.