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# The role of floor control and of ontology in argumentative activities with discussion-based tools

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**Abstract** Argumentative activity has been found beneficial for construction of knowledge and evaluation of information in some conditions. Many theorists in CSCL and some empiricists have suggested that graphical representations may help in this endeavor. In the present study, we examine effects of type of ontology and of synchronicity in students that engage intuitively, without training, in e-discussions. Fifty-four Grade 7 students from two classes participated in the study. We tested the effects of using an informal argumentative ontology and control over turn taking on the average number of claims and arguments relevant to the issue at stake, the average number of different types of references to peers (productive. etc.), and on the number of chat expressions (nicknames, swear words, etc.). We found that when providing both an informal argumentative ontology and control over turn taking, students express less chat expressions and fewer references that are not new relevant claims or arguments to their peers, but express more relevant claims and arguments. These findings suggest the immediate beneficial role of the combination of an informal ontology and control over turn taking in the co-elaboration of knowledge.

**Keywords** Argumentation · Knowledge construction · E-discussions and learning

## Argumentation, knowledge construction and CSCL tools

Since antiquity, argumentation has been considered a powerful tool for knowledge construction. Plato's dialogues (or Socrates' dialogues) such as Meno or Protagoras show how critical discussions may help participants reach 'eternal truths.' Although such dialogues do not seem psychologically realistic, these texts (as well as other canonical texts) have to a large extent influenced Western culture, which values argumentation as a

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central tool for knowledge construction. Some experimental settings have corroborated this belief (Kuhn et al. 1997; Pontecorvo and Girardet 1993; Schwarz et al. 2000). However, empirical studies have raised ontological issues about argumentation such as 'which moves in conversation are argumentative?' or 'whether argumentation involves substantive conflict?' (see Burnett 1993). A definition of argumentation according to a model of critical discussion (e.g., van Eemeren et al. 1996) seems too strict, while a definition that includes any discursive activity in which intersubjectivity is attained (Miller 1987; Rogoff 1990, 1998; Antaki 1994) is too loose to lead to empirical insights. Research on argumentation is then focused not only on conditions in which argumentation leads to knowledge construction, but also on the ontological components included in each study.

Besides these theoretical considerations, important contributions to research on argumentation have been reached in developmental psychology and in education. Developmental psychologists such as Stein and colleagues (Stein and Miller 1993; Stein and Bernas 1999) have shown that since early childhood people are very fluent at arguing in social settings. In contrast, Kuhn (1991) has shown undeveloped *argumentative* skills among adolescents and adults without higher education. This apparent contradiction is understandable when comparing the contexts of the two studies: disputes (a social context) for Stein and Miller, and structured interviews (an academic context) for Kuhn. People know how to argue in order to attain goals important for them such as winning, impressing others, excusing themselves, etc. People have difficulties arguing when they don't perceive valuable goals.

Research on argumentation and education has shown other interesting results. It is difficult to sustain argumentative activities in classrooms for constructing scientific knowledge (in a Vygotskian sense) (e.g., de Vries et al. 2002). Proper design can help in orienting students (providing them proper goals) leading them to argumentation and eventually construction of knowledge. Among the design strategies possibly leading to argumentation: pairing peers with different initial cognitions (Glachan and Light 1982), providing hypothesis testing devices (Howe et al. 2000; Schwarz and Linchevski 2007) and the choice of appropriate tasks that have the potentiality to engender diverse explanations (van Bruggen and Kirschner 2003; Schwarz et al. 2000).

These design strategies have often successfully led to initiate argumentation. However, pursuing argumentative moves is very demanding. An important design effort has been invested to remedy this weakness: the elaboration of technological tools that structure student's representation of their own reasoning/argumentation. Bell (1997) has recognized two different types of representations of argumentation, since these representations may point (a) to argumentation structures, or (b) to argumentative processes.

The first type, *knowledge representation tools*, supports the construction of argumentation whose structure and content correspond to a valid argument. Examples of such environments are SenseMaker (Bell 1997) and Belvedere (Suthers and Weiner 1995). The ontology of the representations generally displays viewpoints, reasons, and data or backing separately according to a Toulminian terminology of argumentation. Suthers (2003) notes that environments such as Belvedere provide representational guidance—that is a set of *constraints* and *saliences* (or *affordances*)—that initiate the negotiation of meaning, serve as a representational proxy for purposes of gestural deixis and provide a foundation for implicitly shared awareness.

The second type, *discussion-based tools*, consists of graphical representations of argumentative moves of participants in discussions, that is, of argumentative processes. As such, displays are personalized. The CSILE environment (Scardamalia and Bereiter 1994) is a well-known discussion-based tool whose representations are extremely simple

(one box for each intervention and arrows to refer to previous interventions). When discussing an issue, students are required to enter notes with identified types of content: "My Theory," "I need to understand," Comment." Each CSCL argumentative environment is designed to enable a new discussion space, new ways of negotiating and co-constructing meanings. As is the case for knowledge representation tools, choices must be made concerning the ontologies available, the ways to communicate among participants (the modalities), the tools available to evaluate, and the role of the teacher.

Although from a theoretical point of view the distinction between the two types of environments is worthwhile, it is not always a clear-cut distinction and tools representing structures as well as processes are used. Particularly fruitful 'hybrid' tools have been designed in science education. These tools provide general structures for the articulation of arguments (Bell and Linn 2000; Suthers and Weiner 1995) or building models (Jackson et al. 1994). Sandoval (2003) constructed a tool, the Explanation Constructor, which provides explanation guides that represent visually a sequence of separate components of explanations marked by prompts that rhetorically and conceptually joined components together. Explanation guides are an epistemic form, a particular knowledge representation that affords particular epistemic games, reasoning strategies and manipulations of the representations that allow particular forms of knowledge construction. Sandoval proved that the epistemic form of explanation guides help students to play the epistemic game of constructing coherent, well-supported causal explanations.

Our starting point in the present paper is the recognition that the use of representations of argumentation has been shown to be successful at mediating construction of knowledge. For example, Schwarz et al. (2003) have shown that the use of a knowledge representation tool by triads to discuss a moral issue has led to knowledge construction. Sandoval (2003) has shown that the Explanation Constructor is productive in the elaboration of the scientific concept of natural selection. This general tendency needs to be clarified though. We know that communication and interactions in face-to-face conversations and in computer-mediated communication (CMC) are of a different nature. We also know that rules of communication can be easily established and modified in CMC. The theory of representational guidance has been tested in empirical studies (Suthers and Hundhausen 2003; Toth et al. 2002) and shows that the saliency of types of information in representational notations affords the elaboration of different kinds of knowledge construction. In other words, students are influenced by representations in the elaboration of knowledge. If this is so, an important issue is, of course, what to design. And in order to know what to design, we need to observe the elaboration of knowledge with different kinds of argumentative tools; the kinds of argumentative tools should be decided according to the identification of crucial factors that, according to theoretical considerations, should have effects on the co-elaboration of knowledge. One of the most intriguing aspects of this kind of research is that, as mentioned earlier, the nature of argumentation and the ontological components that constitute it are not agreed upon. We seize then the stick by its two ends, since we both observe how discussants use representations and how to represent argumentation. The theory of representational guidance functions as an initial theory for the design of tools in a design research process (Edelson 2002). As a design research program, the present study is intended to lead not only to design suggestions, but also to the refinement of the theory on representational guidance in the case of the use of argumentative tools.

In the present study, we observe the elaboration of knowledge with argumentative tools in one of the most natural contexts: solving daily-life issues and dilemmas. This domain is untapped since the use of argumentative tools has generally been tested for the acquisition

of scientific knowledge. Rogoff (1990) has shown the importance of discussions around daily-life issues in human development. These discussions traditionally take place in face-to-face conversations. We believe that since informal conversations are now ubiquitous with CMC systems, e-discussions around daily-life issues are also central. Like in face-to-face conversations where discussants are often not taught how to discuss, we focus here on e-discussions in which the discussants are not instructed how to use the tool. In this context we check how modifications of design of an argumentative tool influence knowledge co-elaboration.

## First steps to study how argumentative tools influence knowledge co-elaboration: The role of ontology and synchronicity

Our starting point is that forms of communication provided by argumentative tools influence the co-elaboration of knowledge. Our aim in this paper is to study several variables that are crucial for this co-elaboration. A priori, among the characteristics of argumentative environments, the most central is the kind of ontology proposed: the design of argumentative representations is based on the hypothesis that the ontology facilitates the elaboration of arguments because learners will see their task as one of making acceptable representational artifacts out of this ontology (Suthers 2003). There are many possible choices of ontology, which belong to two main types. Informal ontologies represent categories borrowed from reasoning in conversations. As mentioned above (Stein and Miller 1993), from early childhood, people know to justify, to agree, to oppose or to challenge in natural settings. Argumentative representations may provide informal ontologies to make explicit these categories when participating in e-discussions. Of course, students may not use the categories borrowed from reasoning in conversations in their e-discussions in the same way as they participate in face-to-face conversations. However, this ontology is hypothesized to encourage informal reasoning strategies in school. Another type of ontology, which we call educated ontologies, concern categories that are learned mostly in school. For example, students learn theory- and data-driven hypothesizing in the science classroom. Even if students have some intuitive knowledge about these actions, they learn their definitions and rules of application systematically at school. In each scientific domain (Science, History, etc.), professional scientists have described how reasoning should deploy in talk (e.g., Bloch 1949 and Colingwood 1946 in history; Driver et al. 2000 in science). Such norms define the (educated) ontology in each domain. Designers of computer-mediated communication (CMC) learning environments can decide whether to propose any ontology at all in order to invite students to be explicit about their reasoning. Designers should then decide between three alternatives: without ontology, with informal ontology, or with educated ontology. To our knowledge, no systematic study has been done on the effect of ontology on co-elaboration of knowledge. The present study is a first step in this direction: we compare co-elaboration with and without ontology. We focus on informal ontologies, and do not study the use of educated ontologies, which demands the implementation of an educational program.

So far, we used the term ‘ontology’ as if it is well defined for each domain. But here also, choices must be made by designers about the actions to be ‘afforded.’ In the case of informal ontologies, researchers have proposed categories for analyzing reasoning in conversation. For example, Resnick et al. (1993) decided on categories for the social distribution of argument (elaboration, objection, concession, statement of position) and for the structure of reasoning (conclusion, premises, factual implied premises, with links such

as questions, answers, examples, or generalizations, to constitute arguments or challenges to them). While this categorization inspired us for choosing categories for informal ontology, we were sensible to the fact that in our case categories are for use and not for analysis. Our approach was to simplify and to do what is of course forbidden for analysis: to merge between social and argumentative discussion. In a design process, we checked several possibilities by providing tentative ontologies and interviewing students. For example, we chose the category "claim" for expressing standpoints and the category "argument" for including a claim and reasons supporting it. With these two categories it seemed superfluous to add categories for reasons. However, many students preferred to make public their claims and to explain their reasons as reactions to interventions from their peers. Other students preferred to write a full argument right away. Also, even discussants that used the category "argument" needed to express reasons, for example when defending their already expressed arguments. Consequently, we decided to provide the categories "claim," and "argument" as well as categories for reasons. We thought about two kinds of reasons for supporting standpoints: "evidence" and "explanation" (Kuhn 2001; Glassner et al. 2005) (factual and theory driven premises for Resnick and colleagues). However, students often did not understand the meaning of the term "evidence."[1] This observation led us to propose the terms "explanation" and "information." Interviews of students in the course of the design of the tool led us to add a neutral category, "else," through which students express comments, remarks etc. without being specific about their function in the e-discussion. To encourage social interaction, we decided to use arrows to "refer to." We thought to use three kinds of reference: supporting, opposing, and relating. We thought that when asking questions or clarifications, students will use referring arrows. However, they used supporting or opposing arrows and not relating arrows. The 'informal ontology' we decided on then, consists of "claim", "information", "explanation", "argument", "else" and references that express support and opposition. All such categories may have both a cognitive and communicative aspect. For example, the support may be used to back your own claims or claims expressed by others. The important thing is that the tool afforded these two aspects. The support and opposition arrows were intended to afford evaluation of your own or others' utterances.

It is clear that our choice of informal ontology did not prevent students from misusing it. For example, we noticed that sometimes students used the category "information" to write a personal explanation. This observation echoed Kuhn's (1991) findings about 'pseudoevidence,' according to which students often mix up personal views with 'facts', or elaboration of a claim with its reason. In other cases, the use of the category "information" seemed to be used as a rhetorical stratagem to impose a personal view. Also the use of the category "else" sometimes looked like a question, but was an elegant way to set an indirect opposition. We do not see these misuses as shortcomings in our choices; in many cases the term "misuse" seemed to us inappropriate. The issue that we ask in the study is not about the appropriateness of the intervention to the category chosen but about the usefulness of providing an informal ontology for the co-elaboration of knowledge. We hypothesized that even if sometimes students fail at fitting interventions to their appropriate category, the informal ontology we chose affords a better elaboration (we define the term 'better' later on). As we intended to focus exclusively on an informal ontology and not on any kind of

[1] We currently use the term "evidence" in an educational program in which students are explicitly taught to distinguish it from "explanation." We also teach other argumentative components. This program then enables the use of one kind of educated ontology.

educated ontology, we observed the intuitive use of informal ontology, without any preparation or intervention.

The second natural step in the study of the influence of argumentative tools on the co-elaboration of knowledge concerns the synchronicity in communication. Social spoken argumentation is a synchronous process during which joint attention is ideally maintained. Turn taking is central in this endeavor. Turns in talk are determined in different ways: facial expression, pause of the other, intonation, or simply interruption. Turn-taking in collective argumentation, and in general in spoken conversation, follows a normative ideal of *precisely alternating turns*. The word 'precisely' refers to the timing of the transition from one speaker turn to the next, which is ideally supposed to occur with no (or minimal) gap, and no overlap between speakers (Sacks et al. 1974). 'Alternating' refers to the expectation that participants will take turns speaking in an orderly fashion; thus in dyadic exchanges, one person speaks, the other responds, the first speaks again, the second takes the following turn, and so forth. In small group conversation, overlaps can occur but they generally occur through gestures, facial expressions, etc. Descriptive studies of computer-mediated communication (CMC) exhibit numerous violations of both the "no gap, no overlap" principle and the principle of orderly turn alternation, unless floor control in turn-taking is ensured (automatically, by a tutor or by the discussants themselves). Concerning gaps, there is often a considerable time lag between when a message is sent and when it is responded to, especially in asynchronous forms of CMC. Synchronous CMC involves more rapid exchanges of turns, but delays may be caused by disrupted turn adjacency. Overlap in CMC is also problematic. In dyadic communication, users, unable to tell whether their interlocutor is in the process of responding or not, may become impatient and send a second message before a response to the first has been received, resulting in incomplete or interleaved exchange sequences (Condon and Cech 1996; Marvin 1995). In group communication, unrelated messages from other participants often intervene between an initiating message and its response (Murray 1989). According to Herring (2001), these problems are responsible for incoherence and for topic decay—the fact that discussants rapidly discuss less and less the topic at stake during e-discussions.

Despite the numerous shortcomings of synchronous CMC systems as conversational environments, they are often viewed as more socially desirable than analogous face-to-face interaction—in Walther's (1996) term, as 'hyperpersonal' rather than as 'interpersonal' interaction: weakening of coherence between messages induces humorous style. The fact that in contrast with spoken discussions, no norms are prescribed on discussants enables them to participate in parallel discussions and to play. Reduced feedback and loosened adjacency enable a qualitatively different kind of interaction from spoken conversation, and this contributes to CMC's 'hyperpersonal' appeal. To grasp the social character of CMC messages researchers have defined the term *social presence* as "the salience of the other in a mediated communication and the consequent salience of their interpersonal interactions" (Short et al. 1976). Several researchers studied the contents of CMC messages to show the presence of affective as well as interactive–cognitive expressions (Rourke et al. 1999). A three-component tool was elaborated for measuring social presence: (a) *emotional responses* that include uses of *emoticons*, humor, self-disclosure, etc.; (b) *interactive responses* that include continuation of a thread, referring to or quoting from others' messages, asking questions, complimenting or expressing agreement, etc; and (c) *cohesive responses* that include phatics (expressions of sociability), vocatives, etc. With such a tool, Rourke et al. (1999) could show that asynchronous e-discussions are deeper and more filtered (with less emotional and more cohesive responses) since delay causes more reflection by less social involvement. On the other hand, students enjoy synchronous

discussions more. Thus the "attractions" of CMC can be seen as the flip side of the "incoherence" coin-loose inter-turn connectedness and overlapping exchanges have both advantages and disadvantages, depending on the purposes for which users engage in computer-mediated interaction.

This short review suggests that in e-discussions, rules of communication are very different than in spoken discussions. It also suggests that the type of synchronicity adopted modifies interactive processes. The interactive process of co-elaboration of knowledge with argumentative tools is not an exception. The review seems to suggest that argumentative tools are not good mediators for the co-elaboration of knowledge in comparison with face-to-face communication. However, playful and multi-interactional possibilities of CMC systems are based on the availability of a persistent textual record of the interaction in most forms of text-only CMC. Even the least persistent synchronous interface is more persistent than spoken language, which disappears immediately once it is uttered. Persistent conversation aids the user's cognitive processing. The predilection towards meta-humor and meta-play in CMC can be attributed in part to the fact that CMC persists as text on a screen and is subject to conscious reflection in ways that spoken language is not, thereby facilitating a heightened meta-linguistic awareness (Cazden 1995). Users are able to participate in simultaneous multiple interactions without getting hopelessly lost or confused because there is a typed record to which they can refer to keep track of what is going on.

Different types of synchronicity have been considered so far with argumentative tools. The first type enables e-discussions in which all participants can intervene whenever they want. Participants may insert their interventions simultaneously without paying attention to the interventions of their peers. This simultaneity is identical to what happens in chat-discussions. The second type enables e-discussions in which participants (or a tutor) establish turns for interventions; whenever one participant inserts an intervention, others cannot write any contribution. Such a constraint does not ensure joint attention, since students can prepare themselves for a further intervention without following all interventions before their planned turn. Although these types of e-discussions are not fully synchronous because of the delay caused by floor control, we still consider them to be synchronous as the possibility to intervene is close to immediate. Argumentative tools enable another type of synchronicity: asynchronous e-discussions in which students participate in forums and interactions can spread out for hours, days or weeks. For each of these types of synchronicity, the interactive processes involved in collective argumentation seem different from natural conversations. For example, joint attention is never guaranteed, and the 'shared thinking' that has been identified as characterizing argumentation by several social psychologists (Rogoff 1990; Miller 1987) seems at least very different in CMC collective argumentation.

Studying the role of types of synchronicity with argumentative tools is an exciting direction, especially in relation to the use or non-use of informal ontology. On the one hand, the delay caused by floor control may cause similar effects to asynchronous discussions–more elaborated discussions. When combining floor control with use of an informal ontology, it is reasonable to expect even more elaborated discussions caused not only by the delay inherent in floor control but also by the action of choosing an appropriate category. It is reasonable to characterize social presence by interactive expressions. On the other hand, discussions without floor control and informal ontology may lead to social presence characterized by emotionally less-filtered expressions (similar to chat and face-to-face interactions).

What we claim here is no more than reasonable hypotheses to be checked. The combination of informal ontology and absence of floor control, or of no ontology with floor

control are difficult to predict as two influences seem to be in conflict. The present study constitutes a step to investigate the influence of argumentative tools on co-elaboration of knowledge by considering synchronicity and ontology as independent variables. This study was done as a part of a research design project: the DUNES project.

During the design of the DUNES environment, we undertook a pilot study to investigate according to which dependent variables co-elaboration of knowledge could be measured (Schwarz and Glassner 2007). In this pilot study, two types of settings were formed: some discussants were provided the same shapes for all their interventions (i.e., there was no ontological meaning the one shape; it was without ontology), and other discussants were provided a variety of differentiated shapes for different argumentative moves (informal ontologies). Each participant worked on a personal computer and participated in a full class activity led by the teacher. The teacher organized turn taking as a pre-established round of turns. Each student prepared his/her intervention on his/her computer; then, when his/her turn arrived, she/he went by the teacher whose computer was connected to a video-screen and entered his/her intervention. Oral discussions were also allowed. Two small groups of junior high-school students discussed ethical issues. We showed that in order to trace the elaboration of knowledge, it is useful to identify arguments in argumentative (discussion) maps and references of participants to others in elaborating them. We showed that providing an informal ontology helped construct more reasoned and broader (with more perspectives) arguments, and with more references to peers' previous interventions. In the design of the beta version of the DUNES system (see next section), we aimed at providing an informal ontology and two types of synchronicity: participating in the same e-discussion online (a) without floor control (each participant enters his/her intervention whenever he/she wishes so) and (b) with floor control (a round of turns is posted; it corresponds to the time order of requests for interventions).

## Description of the dunes environment

The DUNES environment is a CSCL argumentation representation (discussion based) tool. In order to motivate students to engage in discussions, we followed the advice of several researchers (van Bruggen and Kirschner 2003; Schwarz and Glassner 2003) to propose 'cases' to students (also called 'ill-structured' or 'wicked problems'); that is, problems for which (a) there is no unique expected answer, (b) the ways to progress to an acceptable solution are varied and (c) participants have some informal knowledge of the issue to be debated. Moreover, we presented cases that arose curiosity among participants. To do so, we often used a narrative from daily life. We hypothesized that such characteristics trigger students' engagement in argumentative activities. We asked teachers to initiate cases through a verbal introduction or through the DUNES Oasis, a web portal for the preparation of materials. The Dunes Oasis is intended to be used as a platform for (a) initiating asynchronous or synchronous communication (with or without floor control) with application sharing, voting, chat, and other communication services; (b) launching a client-based graphic discussion map (presented later on); and (c) setting and editing learning materials for all users.

The script of a case contains definitions for the schedule, pedagogical goals, content-related goals, etc. An example of a content-related goal is to differentiate between the role of primary and secondary texts in the elaboration of interpretations in history issues. The pedagogical goals are often non-content-related goals, but not always. Examples of non-content related goals are learning how to negotiate, or how to argue, about reaching a better

understanding of how we trust (or do not trust) what somebody is telling us, etc. The pedagogical goals are very often implicit for the users. In the design of a case, instructors decide on the social settings of activities such as the size of groups of discussants (small groups of two to six, whole group forum, or individuals). We now turn to the representation of discussions in the DUNES environment realized in the Digalo web tool. Since the research will focus on how students discuss with Digalo, the terms DUNES and Digalo will be used interchangeably.

Digalo (http://zeno8.ais.fraunhofer.de/digalo/index.html) is a central component of the DUNES system (http://www.tessera.gr/dunes/index). Digalo enables the management of discussions and the representation of their argumentative processes and components among participants. Using Digalo consists of co-creating maps built of written notes inside different shapes that represent the building blocks of the ontology chosen, and different arrows representing different connections between the shapes. Shapes may have attachments and links to external web resources and connections to the library. Every map has an ontology that specifies and constrains not only the admissible labels for the shapes (such as opinion, fact, reason, defending, challenging), but also the different 'roles' to be played when manipulating the map. The choice of ontology is intended to create a discussion space that constrains how the discussion can develop. Moreover, the choice of the ontology is naturally content sensitive. For example, the ontology suitable for scientific critical reasoning is inadequate for discussions in social or historical domains. Figure 1 displays the default list of possibilities for creating ontologies (which can be easily changed in order to represent any other possible ontology).

When using Digalo, the facilitator of the discussion (generally the teacher or the designer but in some cases a student) presents a blank map, and decides on the ontology to be used in e-discussions.

Digalo enables three types of synchronicity: (a) synchronous e-discussions with floor control (FC), (b) synchronous discussions without floor control, and (c) asynchronous

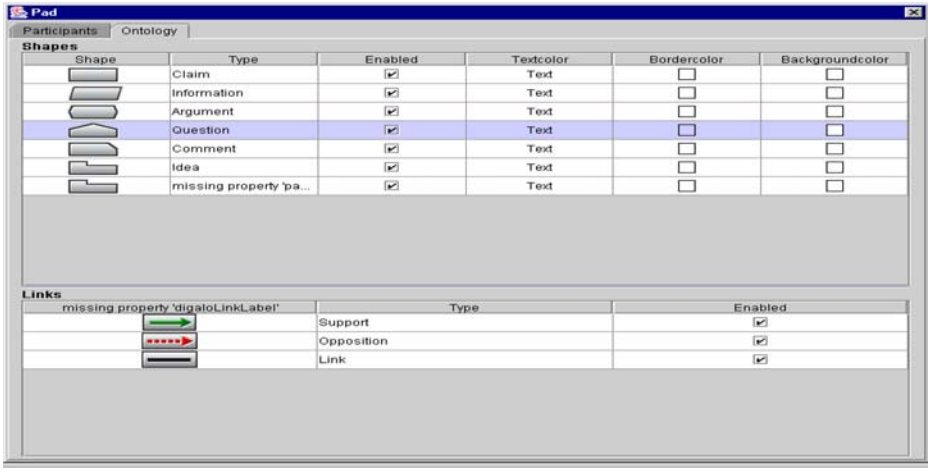


**Fig. 1** The creation of an ontology for Digalo

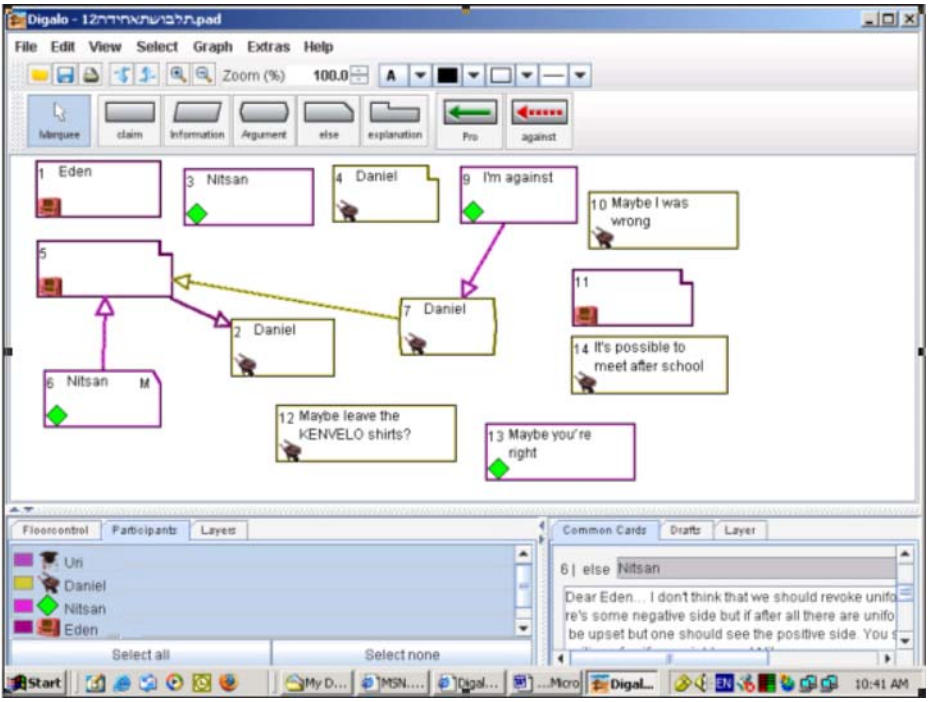


**Fig. 2** A Digalo map (the map of Nitsan's group)

discussion. Since we focus here on synchronous e-discussions, we explain in detail these two types:

- When FC is activated, only one person can work on the board (add shapes and edit the text in a shape). The first to request FC will receive it immediately, and others will enter a line for receiving FC. As soon as the student finishes writing his/her contribution, s/he releases FC (by clicking on the "Release floor" button) and by doing so, allows other students who requested FC to add contributions; the next turn is taken by the student who asked it first.[2]
- When FC is deactivated, all participants can work simultaneously, without taking turns.

In each of the contributions, participants add one or more shapes and arrows/links to shapes built by others to articulate claims, arguments, etc., *then* they write their contribution. Each participant can locate his/her contribution wherever he/she wants on the screen and change the location of previous shapes. Each participant chooses a distinctive color and an icon that help identify his/her contributions on the board. Figure 2 shows the ongoing construction of a map with Digalo. The lower-left window displays the names of the four discussants (Uri, Daniel, Nitsan and Eden) and their distinctive signs. Clicking on the "floor control" would have displayed an ordered list of names representing requested turns, which changes as the discussion develops. We can see in Fig. 2 that

[2] There is an option to nominate a facilitator whose role is to decide whether one student will receive FC before others or vice versa, or can take FC from a student if he/she thinks this is necessary. The teacher often takes the role of facilitator, for example, to allow collaboration when some discussants are dominant. One of the students may also be conferred this role. In the present study, this option was not chosen.

although discussants have distinctive signs, they often post their names in the titles of the shapes (turns 1, 2, 3, 4, 6, 7) and leave the contents of their interventions in the comments. These comments are visible when putting the pointer on the shape or when one double-clicks on the shape. The comment appears then in a lower-right window like in Fig. 2, for the comment of turn 6 (by Nitsan as a reaction to Eden, materialized by an arrow).

In classrooms, students participating in synchronous discussions with or without FC generally sit in the same room, each participant with his/her personal computer. The teacher or the students form groups of discussants beforehand. In each discussion group, all participants see the actions of their discussion group only as they happen synchronously. Generally, several discussion groups operate in parallel. Although groups may also interact verbally, in our study, discussion groups were requested to communicate through Digalo only. In two recent long-term studies in History classes, the use of Digalo in synchronous discussions with ontologies has been found to be highly productive (Muller Mirza et al. 2007; Schwarz and de Groot 2007). Other studies have shown the beneficial role of asynchronous discussions with another graphical tool for argumentation. The nature of the gains and the ways to measure them were different in the three studies (Schellens et al. 2007). However, these findings suggest that studying the role of ontology and synchronicity is important.

## Description of the research

The general research question was to what extent floor control in turn taking and informal ontology are beneficial to the co-construction of knowledge. Focusing on informal ontology led us to propose discussion on a non-scientific issue and we decided to opt for a moral issue. By the term "beneficial," we meant both to the object of the discussion and to the discussion as a process. From the perspective of co-construction of knowledge, it is natural to identify claims (conclusions, opinions, and viewpoints) and arguments; that is, claims with reasons supporting them. Many times, however, the expression of claims or arguments was implicit and while we had sometimes the intuition that their expression eventually led to elaboration of knowledge, these intuitions did not rely on firm criteria. This ambiguity led us to adopt two different approaches to analyze e-discussions. The first approach was more "experimental": We considered the questions we asked by identifying independent and dependent variables. According to this approach, explicitness was central; it helped identify claims and arguments. Explicitness could be expressed through words and through shapes and arrows that sometimes completed the content of interventions.

As for the process of *co*-construction, it raises the same kind of ambiguity. On the one hand, the concept of social presence we defined at the beginning of the article provides possible tools for observing collaboration. It is possible to identify references to interventions by others and emotional and cohesive responses. Of course, deciding on what is beneficial in references to others and in emotional responses is a very problematic issue. However, explicitness can again somewhat help: we considered references as beneficial for co-elaboration of knowledge when explicitly accompanied by a new relevant claim or argument. When explicitness was missing, the status of references was not clear with respect to co-construction. Therefore, we called the first kind of reference 'productive' and did not name the second one other than 'reference to peers.' As for the emotional and cohesive responses, we called them chat-style expressions because they characterize chat communication (Herring 2001). A priori, we hypothesized 'productive' references would be beneficial. We did not have clear hypotheses about whether other references and chat-style

responses are beneficial or not. However, we decided to code these data since they may characterize discussions in different conditions and this characterization may contribute to theoretical considerations about what counts as beneficial in e-discussions. All detailed criteria that define benefits of e-discussions are presented later on.

We hypothesized that the use of informal ontology would be beneficial since an informal ontology invites discussants to be explicit about the role of their intervention in discussion. Moreover, the delay caused by the need to choose a shape before writing their intervention has the potential to invite students to reflect on their intervention with respect to the discussion whose textual form is visible (see Schwarz and Glassner 2007, for evidence of such an occurrence). We hypothesized then that explicitness and reflection should lead to the writing of more relevant claims and arguments and greater reference to other students. Our hypothesis on the beneficial effect of an informal ontology was also based on the pilot study. Concerning the presence or the absence of floor control, we knew that constraints of keyboard communication might put off knowledge negotiation (Clark and Brennan 1991). On the other hand, the design of the DUNES system was done by companies specialized in interface. We hypothesized then that the design was good enough to enable fluent communication between users. We hypothesized that floor control invites discussants to delay their reactions, to plan interventions, to post them when ready, to refer to previous interventions, and to elaborate more relevant claims and arguments[3]. We hypothesized that synchronous e-discussions without floor control would lead to more chat-style writing, especially when no ontology was available; no floor control in synchronous e-discussions invites students to refer quite randomly to previous interventions without pursuing steadily a specific thread of thought (Veerman et al. 2000).

We already mentioned that we did not take into consideration whether discussants chose categories of informal ontology adequately during their discussion. We aimed at observing how students co-elaborate knowledge when they have an intuitive sense of informal ontology. We then did not provide any instruction about this ontology except for a short demonstration of the experimenter (see the procedure sub-section). The issue of educational programs for helping students participating in 'productive' e-discussions is discussed in the concluding section.

## Population

Fifty-four Grade 7 students from two classes in the same school participated in the study. The school is located in a small Israeli city. Achievement in the school is average according to national tests. The students were knowledgeable about common computer applications (Internet, databases, Office tools). The experiment took place within the frame of a course on dialogic thinking and technology at the beginning of the year. The school was highly interested in instilling skills for using sites and discussing texts through electronic channels. Although we invited students to form quartets, many of them preferred to organize themselves according to different kinds of affinities. Since we knew that the success in the experiment relied on students' willingness to participate in an extracurricular activity, we accepted this state of things and the teachers organized students into 12 discussion of 3 to 6 students; students from the same group did not sit together, but the groups were constituted

[3] This hypothesis was not based on empirical results. However, Andriessen et al. (2003) have initiated studies in collaborative writing, which is similar to some extent to participation in e-discussions, mediated by a discussion based tool. He showed that when students are prepared (through brainstorming or the expression of personal arguments in a written form), they are inclined to collaboratively write elaborated ideas in a structured interface.

by the online self-connectivity of the computer environment. The experiment was then, a priori, quasi-experimental.

### Independent variables

The first independent variable was ontology: without and with informal ontology. As a result of design process, informal ontology included the following argumentative components: "claim," "information," "explanation," "argument," and "else" (see above for justifications). Such an ontology fits a context in which students did not learn about argumentation (the distinction between claim and argument is problematic, as mentioned above). The components were embodied in different shapes. In addition, two sorts of arrows were available, arrows that expressed support and arrows that expressed opposition. In the case of no ontology, students had boxes at their disposal, all of them with the same shape, in which they entered text for each of their interventions.

The second independent variable concerned the (non-)activation of floor-control (FC) in Digalo. When floor control (FC) was activated, all students could post their intention to contribute, and the fastest one was provided FC. At the end of his/her contribution he/she pushed the button for FC release and floor control was then automatically taken from him/her and passed to the next student in the turn-request queue. The same procedure went on during the whole discussion. When FC is deactivated, all participants can work simultaneously, without taking turns.

According to the two independent variables, the 12 discussion groups operated in the following conditions (2×2 factorial design):

- For three discussion groups (N1=5; N2=6; N3=5), no ontology was available and there was no FC (no ontology/no FC, labeled NN)
- For three discussion groups (N1=5; N2=5; N3=4), no ontology was available, and floor control was activated (no ontology/FC, labeled NF)
- For three discussion groups (N1=4; N2=4; N3=5), informal ontology was available and there was no FC (informal ontology/no FC, labeled ON)
- For three discussion groups (N1=4; N2=4; N3=3), informal ontology was available with FC (informal ontology/FC, labeled OF)

Therefore, each condition gathers three discussion groups. We call each of the four gatherings of three discussion groups a condition cohort: NN ($N$=16), NF ($N$=14), ON ($N$=13) and OF ($N$=11), accordingly.

### Dependent variables

The dependent variables were: (a) the number of relevant claims (conclusions, opinions, and viewpoints concerning the controversial issue); (b) the number of relevant arguments (i.e., reasoned claims or claims with information or explanation that support them); (c) the number of chat-style expressions; (d) the number of 'productive' references to peers (i.e., references accompanied by a new relevant claim or argument); and (e) the number of other references to peers (when a reference was coded as 'other reference to peer' it did not necessarily mean that it was not beneficial to the discussion, but that the coders were not sure whether the reference contained a new relevant claim or argument). When counting and coding the relevant claims and arguments, we did not refer to the shapes used but to the interventions themselves.

## Procedure

Each of the 12 discussion groups underwent 2 different sessions in the same computer laboratory. Each group was instructed to discuss the controversial issue "whether or not wearing school uniforms at school is binding," by using Digalo. At the time of the experiment, this issue was an actual dilemma and the principal board was interested to know about the students' views. The experimenter and the teachers prepared in advance the different discussion settings (i.e., inserted the names of the participants and defined the representation shapes and arrows and the turns option for each group setting). The experiment took place in the computer lab. For each of the two classes, each student sat by a personal computer.

In the first session, at the first stage, each student was invited to write on paper his/her personal viewpoint on school uniforms and to give as many reasons as possible that support his/her viewpoint. Each student was then invited to create a viewpoint different from hers, and to give reasons supporting this viewpoint. This procedure was thought to lead all students to be committed in their further e-discussion. The second stage of the first session was devoted to familiarization with Digalo: each participant was provided with written technical instructions; the instructions reflected the condition cohort to which the student belonged. Then, each participant within his/her discussion group was invited to write a personal story with the shapes and FC conditions in Digalo that reflected his or her condition cohort.

In the second session, at the first stage, the teacher explained that each student is assigned to a specific discussion group. Therefore, several discussion groups sat in the same room. The teacher scattered students in the lab to prevent students from the same discussion group communicating verbally. The teacher also asked students explicitly not to communicate verbally. All students were instructed to engage in the discussion about the uniform issue through Digalo. They were asked to present first their personal opinions without reacting to each other, and then to continue the discussion and to try to accommodate divergent views. The time for discussion was limited to 20 min. At the second stage, the students were asked to write down their own reasoned viewpoints on the uniform issue as well as the reasoned viewpoint of a possible opponent, in the same format as in the first stage of the first session.

## Collection of data and analysis

The data we collected were the written viewpoints before and after discussion with Digalo and the Digalo maps produced during discussions. We will see in the findings session that the written viewpoints could not be analyzed for procedural reasons. Although it is always possible to combine different interventions to a complete argument, we counted as arguments only interventions in which the discussant linked explicitly a claim and a supporting element (in one box or by using an arrow). The coding was validated by an inter-rater procedure in which three experts first evaluated five maps independently. The inter-rater score was high (0.88). The experts negotiated disagreement until complete agreement was reached. One expert coded the remainder of the maps.

Although we knew from literature on social presence that e-discussions include emotional and cohesive expressions (what we called chat-style expressions), we did not use existing coding systems, but rather adopted a qualitative grounded method for the collection of data enabling an open approach for the definition of categories and variables after a first overview of all the maps. For example, we discovered after the collection of

data different kinds of informal expressions such as pet names or swear words. Such categories helped us defining operationally chat-style expressions. We stress again that we did not check whether interventions fitted the category chosen when students used informal ontology.

Unit of analysis

The unit of analysis of the maps is the written content of each intervention. It includes the title and its adjunct comment. The comment is visible as a window when one participant double-clicks on the box or as a bubble when one puts the pointer on the box. Otherwise, the maps display titles only. In order to analyze maps, we developed a device that produced a script including the creator of each box, its temporal order, its title, comment, and kind of arrow (supporting or opposing) if the discussant chose to refer to another intervention.

Coding of the variables

For each intervention, we asked the following questions: does the intervention include (a) an explicit claim relevant to the issue at stake; (b) an explicit relevant argument; (c) a chat-style expression; or (d) a reference to others' interventions. While for claims, arguments, and references to others we had quite clear definitions to begin with, chat expressions were first coarsely defined as including emotional and cohesive components, and their definition underwent refinement through ongoing elaboration of categories. At the end of the analysis of each intervention, for each of the discussants, we counted the number of relevant claims, relevant arguments, chat expressions, and references to peers (productive and other references).

*Coding the number of relevant claims*

We considered as relevant claims any intervention that expressed an opinion, perspective, conclusion, etc. relevant to the issue. Examples of claims: "Listen, there's no need for uniforms," "I'm against uniforms," "I don't have any opinion on the topic, whether to wear a uniform."

*Coding the number of relevant arguments*

We considered as relevant arguments (groups of) interventions including a viewpoint and reasons relevant to the issue. Examples of relevant arguments were: "I'm against because uniforms are boring, and in my opinion, everybody must be free to choose what to wear," "I'm both pro and con because some children offend others with what they wear and because everybody must look special," "I'm for it because it's fun that everybody looks the same, and because we choose our cloths quickly."

*Coding of chat-style expressions*

We sorted chat expressions according to three categories: use of nicknames, swearwords, and turns from Internet culture. Examples of use of nicknames are: "Ori, the great look," "The Artist #17," "Helen the sexiest, listen to her." An example of a (mild!) swearword is: "Reaction to Nisim's sister". Examples of Internet turns are: "response to Ohad 1," "reaction to Noga reaction to me."

*Coding references to other participants*

References were coded as 'productive' or 'other.' Examples of other references to peers are: "In my opinion, you bother only about yourself" or "You're not right, you're turncoats." Examples of productive references are: "Ohad, Amir, even if uniforms are boring, they can't cause you not to recognize your friends" or "Noga. I think that you're 100% right. I read in the newspaper on a school that decided on uniforms and the students didn't wear uniforms in the same plain way but tore and cut uniforms." Many times examining isolated interventions only left difficult decisions to make regarding coding. The decisions could be made only by considering the interventions in the context of the full map. This is especially true for the coding of references to other peers. For example, the intervention "Ohad, Amir, even if uniforms are boring, they can't cause you not to recognize your friends" previously mentioned could be simply an interpellation. References were identified in relation to content: Ohad and Amir argued previously that wearing uniforms is boring. In a further section, we present an example of coding according to several variables for successive interventions in the context of a full map.

## Results

Table 1 displays the means and standard deviations of the dependent variables for the four condition cohorts.

First, in order to test connections among the dependent variables, we undertook correlation tests.

Positive correlations were found between:

1. 'chat style' and 'other references to peers' ($r$=.421, $p$=.001): the more chat style utterances one wrote, the more references to peers he/she also wrote.
2. 'relevant claim' and 'relevant arguments' ($r$=.595, $p$=.01): the more relevant claims one wrote, the more relevant arguments he/she also wrote.

A negative correlation was found between 'relevant argument' and 'other references to peers' ($r$=−.276, $p$=.05): the more relevant arguments one wrote, the less other references to peers he/she wrote.

Secondly, we performed MANOVA followed by post hoc tests in order to test for effects between the four condition cohorts (NN, NF, ON, and OF). A significant general

**Table 1** Means and standard deviations for outcomes of the four experimental cohorts

| | NN ($N$=16) no ontol./no FC | NF ($N$=14) no ontol./FC | ON ($N$=13) informal ontol./no FC | OF ($N$=11) informal ontol./FC |
|---|---|---|---|---|
| Relevant claims, mean (SD) | 2.06 (1.44) | 2.36 (2.37) | 3.31 (2.10) | 3.72 (2.05) |
| Relevant arguments, mean (SD) | 1.50 (1.32) | 1.29 (0.73) | 1.62 (2.14) | 2.72 (1.68) |
| Productive references, mean (SD) | 0.56 (1.15) | 0.57 (0.85) | 0.85 (1.52) | 1.18 (1.25) |
| Other references, mean (SD) | 1.19 (1.47) | 0.43 (0.65) | 1.08 (1.19) | 0.18 (0.40) |
| Chat-style expressions, mean (SD) | 2.44 (1.63) | 0.79 (1.12) | 0.92 (1.75) | 0.27 (0.65) |

MANOVA effect was found by Wilks' Lambda test, ($F(1, 54)=3.223$, $p=.000$, $\eta^2=.212$). We performed Levene's test of equality of error variances in order to take into consideration differences in the number of subjects in the cohorts and among groups within each cohort. The variances of three dependent factors were found to be significantly unequal: for 'chat style,' $F(3, 50)=3.32$, $p=.027$; for 'relevant argument,' $F(3, 50)=3.22$, $p=.030$; for 'other references to peers,' $F(3, 50)=4.31$, $p=.009$). Following the variances inequalities we performed Welch tests in order to test between-subject effects for these factors. The between-subject tests showed two main significant effects between subjects from different condition cohorts. Significant effects were found with the Welch test for 'chat style' ($F(3, 26.97)=7.37$, $p=.001$) and 'other reference to peers' ($F(3, 26.77)=3.82$, $p=.021$).

The chat style factor

In post hoc LSD tests of the 'chat style' factor, we found significant differences between subjects from the NN (no ontology, no FC) cohort and the subjects from each of the other condition cohorts (with NF, $p=.002$; ON, $p=.005$; OF, $p=.000$). The presence of 'chat style' utterances was found to be significantly higher among the subjects from groups who did not use an ontology and FC than among the subjects from groups who used an ontology, or FC, or both. The largest difference was found between subjects from discussion groups who did not use an ontology and FC (NN) and those who used both an ontology and FC (OF).

The 'other references to peers' factor

In post hoc LSD tests of the 'other references to peers' factor, a significant difference was found between subjects from the NN (no ontology, no FC) cohort and subjects from the OF (with ontology, with FC) cohort ($p=.019$). The average number of other references to peers was found significantly higher among the subjects from groups who did not use ontology and FC (NN) than among the subjects from groups who used both ontology and FC (OF).

The 'relevant claim' and 'relevant argument' factors

Although no overall significant effect of cohort was found concerning the factors 'relevant claim' and 'relevant argument,' LSD post hoc tests showed a significant difference between NN and OF. The average number of relevant claims and relevant arguments among the subjects from OF (with ontology and floor control) groups were found to be significantly higher than among the subjects from NN (without ontology and floor control) groups (respectively, $p=.038$; $p=.045$).

The quantitative results indicate that when students without prior experience with the Digalo tool engage in e-discussions, the combination of using an ontology and activated floor control yield a discussion with less chat expressions and with fewer references that are not new relevant claims or argument to their peers, but yield more relevant claims and arguments. These findings suggest the immediate beneficial role of the combination of informal ontology and control over turn taking in the co-elaboration of knowledge.

## Two examples of e-discussions

The results obtained in the last section indicate interesting directions. However, these directions do not explain whether and how new understandings emerged under different conditions. In this section, we show two examples of e-discussions in which we attempt to trace the emergence of understandings. To ease interpretation, we chose groups in which the number of interventions of

each discussant was relatively high. We chose a small group of three discussants with informal ontology and FC (OF) because it gave the opportunity for more interventions per participant than in a larger group, since the waiting time was shorter. It appeared that the average number of interventions in NN per discussant grew with the number of discussants in the group. We chose then a group that included five discussants. Figure 2 shows the discussion map of three discussants in OF: Daniel, Nitsan and Eden (Uri was an operator for technical help; he was never solicited). The interventions of each discussant are personalized (e.g., Nitsan's interventions are labeled with a lozenge sign). Each participant had his/her personal computer and saw the actions of peers synchronously. The teacher scattered students from the same group in the lab so as to avoid verbal communication. All students were instructed to discuss the issue of the uniform. They were asked to present first their personal opinions, and then to continue the discussion to try to accommodate their views. The time for discussion was limited to 20 min. We list here all interventions in a written format including the creator, the shape chosen, the title, the comment and the arrow(s) the discussant drew. This written format can be tracked in Fig. 2. The first three turns comply with the instructions to present personal opinions:

*Turn #1* *Creator: Eden* *Ontological type chosen: Claim*

*Title: Eden* *Comment: I oppose wearing uniform clothes*

*Turn #2* *Creator: Daniel* *Ontological type chosen: Claim*

*Title: Daniel* *Comment: I'm for wearing uniform clothes*

*Turn #3* *Creator: Nitsan* *Ontological type chosen: Claim*

*Title: Nitsan* *Comment: I'm neither pro nor con although I wrote on the worksheet that I'm pro, I change my mind to the middle, yes as well as no*

We can see that in this first stage each discussant expressed one relevant claim but did not express arguments (reasoned claims) naturally. Discussants chose to use the title to post their names. We turn now to the second stage of the use of the Digalo, the e-discussion:

*Turn #4* *Creator: Daniel* *Ontological type chosen: Explanation*

*Title: Daniel* *Comment: All schools have their uniform clothes, I want it too. It's great*

Daniel judiciously uses the 'explanation' category to elaborate on his initial claim in turn 2. However he does not link his two interventions with an arrow. The arrow is used by Eden in turn 5 to refer to Daniel's turn 2:

*Turn #5* *Creator: Eden* *Ontological type chosen: Explanation*

*Title:__* *Comment: I don't want to wear uniform clothes because not all schools have uniform clothes and this refers to what Daniel said. I don't want to wear a sweater, everybody has his own opinion, and people can't argue on preferences!*

*Link with arrow to: Daniel's turn #2 (support)*

Clearly Eden expresses one claim, *I don't want to wear uniform clothes*, and one relevant argument, *I don't want to wear uniform clothes because not all schools have uniform clothes*,

which is a productive reference to Daniel's previous intervention, *All schools have their uniform clothes* since it includes a new argument and is directed to Daniel. The argumentative function of this reference is a challenge to Daniel's argument. She opposes Daniel although she chose a support arrow (probably mistakenly) and she refers to Daniel nominally. She also adds a new argument, *I don't want to wear a sweater, everybody has his own opinion, and people can't argue on preferences*. This argument is compounded: It includes (a) *I don't want to wear a sweater* (b) *everybody has his own opinion*, and (c) *people can't argue on preferences*. This compounded argument functions as a rebuttal for Daniel's argument. Turn 6 uncovers the same personal, empathic and critical vein:

*Turn #6* *Creator: Nitsan* *Ontological type chosen: Else*

*Title: Nitsan* *Comment: Dear Eden... I don't think that we should reject uniform cloths right away. There's some negative side but if after all there are uniform clothes, one shouldn't be upset but one should see the positive side. You shouldn't reject the proposition of uniforms right away! Nitsan.*

*Link with arrow to: Eden's turn #5 (opposition)*

The claim, *I don't think that we should reject uniform cloths right away*, and the reason invoked, *one should see the positive side* constitute a relevant argument. Nitsan explicitly referred to Eden materialized by an arrow of opposition to turn #5 which was productive since it contained a new relevant reason. Nitsan used the ontological type "Else," though one could have preferred the type "Argument." However, as mentioned earlier, ontology types were intended to provide opportunities to co-elaborate ideas; congruence between the type chosen and its function in the discussion was not crucial. Like previous turns, this turn refers not only graphically but from a content point of view to previous turns. The same tendency continues in the following turn:

*Turn #7* *Creator: Daniel* *Ontological type chosen: argument*

*Title: Daniel* *Comment: to Eden: Like in sport lessons, there won't be long shirts (like in sport we should feel comfortable, for example in high school they supply students KENVELO shirts* [KENVELO is a brand that provides shirts with different patterns but with the same color]*, so I support it.*

*Link with arrow to: Eden's turn #5 (opposition)*

In this turn, there is one relevant argument whose claim is *I support it*, and whose reason, *there won't be long shirts* which refers to Eden's previous turn and as such is a productive reference. Like in previous turns, interventions are reactions to previous turns and go on in further turns:[4]

*Turn #9*[4] *Creator: Nitsan* *Ontological type chosen: claim*

*Title: I'm against* *Comment: Daniel, I think you re wrong because in high school they don't supply KENVELO shirts. They supply the same shirts in all schools and if this is why you accept uniforms I think you should revise your opinion.*

*Link with arrow to: Daniel's turn #7 (opposition)*

[4] Nitsan created a shape then deleted it immediately in turn 8.

Here again, we can see that the congruence between the choice of ontology and its function in the dialogue is questionable: There is an argument whose claim is *you have to reconsider your opinion*, and whose reason is *They supply the same shirts in all schools*. It is a productive reference to Daniel, since the argument is new, and directed to Daniel (both with an opposition arrow and the interpellation *Daniel* and the term *you're wrong*). This turn functions as a rebuttal to Daniel's previous argument since the argument is accompanied by an arrow of opposition and the conclusion *if this is why you accept uniforms I think you should revise your opinion*. This turn is also interesting because Nitsan rebuts Daniel's argument not necessarily because she thinks she is wrong (Nitsan had not yet decided what her position was), but because she detected a flaw in Daniel's argumentation. Nitsan could have chosen the type "Argument" instead of "Claim." From this intervention onward, discussants do not use arrows anymore:

*Turn #10* *Creator: Daniel* *Ontological type chosen: claim*

*Title: Maybe I was wrong* *Comment: But look at the rebels* (a TV series about high school students) *it suits them; maybe we can look nice like them? It's not the main point. They also have one tricot shirt for summer and one buttoned shirt for the winter. I think it will be nice with a uniform*

*Link with arrow to: _____*

Daniel expresses an argument whose claim is *it will be nice with a uniform*, and whose reason is *we can look nice*. This argument is provided an example, *the rebels*. The coders had difficult time deciding whether this new argument referred to a peer. No arrow was drawn and no name was used. Also, the content did not explicitly refer to a previous turn. However, the title *Maybe I was wrong* and the comment: *But...* show a doubt that Daniel begins to have: he was for uniforms in school so far; he expresses his doubt in the title of turn 10, and adds an argument for his (previous) argument. This argumentative move is then a justification. Thus, this turn was coded as a productive reference. As already mentioned, our evaluation of reference (and also to productivity) was based on explicitness. This example was at the boundaries of explicitness. We come back to this problem in the final section where we show that measuring explicitness is still valuable. In turn 11, Eden does not use an arrow too, but clearly refers to Nitsan:

*Turn #11* *Creator: Eden* *Ontological type chosen: Explanation*

*Title:___* *Comment: You don't understand! The uniform is not of a "yes & no" stuff* (KENVELO means 'yes and no' in Hebrew)*, it is just a shirt like sport shirts.*

*Link with arrow to: _____*

This turn includes one argument whose claim is *you don't understand*, and whose reason is *The uniform is a shirt like sport shirts.* It seems to refer to a non-adjacent turn, as its content is directed to Nitsan who opposed Eden's turn 7 about the KENVELO clothes. It is not new since it only clarifies turn 7, since Nitsan understood that Eden means that the uniforms will come from the KENVELO brand, and Eden clarifies that the uniforms will be like KENVELO brands. So this reference was not coded as 'productive' but as 'other.' We suggest that no arrow was used in this turn and in further turns since students understood each other as they clearly referred to previous interventions through words and names.

Since FC is activated, interactions are sequential, so that temporal adjacency is sufficient to determine coherence. We suggest that in the present discussion, additional arrows could have excluded discussants to which the arrow would not have been directed, and at the end of this discussion the three discussants felt that they 'shared their thinking.' This interpretation is strengthened by the fact that Eden's clarification is done on an argument which she opposes (while this phenomenon is comprehensible, the presence of arrows is preferable especially for co-constructing arguments and reflective activities—see Schwarz and Glassner 2007). Anyway, although no arrow indicates the reference of turn 12 to previous turns, it clearly capitalizes on previous interventions:

*Turn #12 Creator: Daniel Ontological type chosen: claim*

*Title: Maybe leave the KENVELO shirts?*

*Comment: Really, leave these shirts. It s not the main point. The question is whether you want or not uniforms. You must think about it, we don't need to think every morning about what you should wear, or if by mistake, you wear clothes that don't fit and that make others laugh at you...*

*Link with arrow to: _____*

The title indicates that the turn refers to the previous turns about KENVELO shirts. This intervention includes a claim *It's not the main point [why people are for or against uniforms in schools]* and a compound argument whose claim is implicit (*I am for uniforms*) and whose reasons are *we don't need to think every morning about what you should wear* and *by mistake, you wear clothes that don't fit*. The claim and the argument are new and are clearly directed to Nitsan although no arrow is drawn. This intervention was then coded as a productive reference. In the following turn, turn 13, no arrow is drawn but Nitsan explicitly writes the name of her interlocutor, Daniel:

*Turn #13 Creator: Nitsan Ontological type chosen: claim*

*Title: Maybe you re right*

*Comment: Daniel, there is something in yours ideas but try to imagine that you buy a new shirt and you desire to show it to everybody and because of the uniform, you can't do it. Depressing, right? I'm not against uniform and I'm not pro because there are advantages because it s fun and you don't need to choose clothes in the morning and children who have money will not be ashamed with their clothes. But as I said before, there are drawbacks, as I said, you buy a new shirt and you can't wear it and you really wish everybody to see it fits depressing for you wish to show the new clothes...you see everything has drawbacks and advantages. If people wear uniform you should look at the good side of it, and if not, you also have to see the good side.*

*Link with arrow to: _____*

In this turn, Nitsan refers to a peer (Daniel), and incorporates two new arguments: opting for uniforms opposes free choice and is then depressing, but helps rich people not to be ashamed of their new clothes. The turn is then a productive reference to Daniel. Importantly, we can see here that Nitsan adds not only ideas but also arguments previously raised by her peers: she uses the argument raised by Daniel that *you don't need to choose clothes in the morning*.

*Turn #14 Creator: Daniel Ontological type chosen: claim*

*Title: It's possible to meet after school Comment: After school it's possible to meet in parties, etc*

*Link with arrow to: _____*

It is not clear whether this turn refers to a previous turn. It is also difficult to decide here whether the claim is relevant or not to the issue at stake. One could figure out that Daniel, who was for wearing uniforms at the beginning of the discussion and emitted a doubt at turn 10, argues now that without uniforms, *After school it's possible to meet in parties*. But this new idea was not explicit and the interpretation could be different. We decided not to code it as a relevant claim/argument.

For those, like us, who are used to analyzing collective argumentation, this discussion is unusually quiet, with many references to previous interventions, and new arguments emerging during the discussion. This general impression is confirmed at the individual level. For example, Nitsan's interventions sum up to: one claim in turn 3 and one in turn 6; one argument in turn 6 and one productive reference in turn 6; one claim, one argument and one productive reference in turn 8; and two claims, two arguments and one productive reference in turn 12. The three references to Eden and Daniel are productive and they led to the elaboration of new arguments. Nitsan's interventions did not include any chat-style expression. We could also discern that the discussion progressed: Nitsan added many new arguments in her reasoning. Daniel turned to be less categorical in his position and also added new ideas. And at the end of the discussion, the students shared their thinking. For example, in turn 11, Eden, who remained against wearing uniforms, clarified an argument she did not agree with to help the discussion to progress. New claims and arguments emerged throughout the discussion, from beginning to end.

We describe now a group of five children who discussed the issue of uniforms in school without ontology and without floor control (cohort NN). The map produced is displayed in Fig. 3. The absence of shapes and arrows makes the transcription simpler than in OF:

1. Shiran: Title: "Listen." Comment: "In my opinion, uniforms are not a must for a lot of reasons. In my opinion all children have the right to express themselves and wearing uniforms doesn't let children express themselves and be prominent in society. Except from that uniforms will not solve money or social problems for many children because they will still compete on shoes, rings, or haircut. It's clear that if there are uniforms in the school it won't improve the situation in the school."
2. Aviel: Title: "In my opinion, wearing a uniform is not a very good idea because everybody must choose clothes to wear, and others cannot decide instead of them, and also people go to school to learn, not to wear uniforms"
3. Yair: Title: "Amazing Yair's box. Worth reading". Comment: "I strongly oppose wearing uniform because many children don't want uniforms since they have a lot of other cloths and in my opinion it's impossible to decide for people what to wear"
4. Helen: Title: "I am for the uniforms because it's handier and because fashion is crazy and because now girls dress themselves like whores."
5. Shiran: Title: "Shiran to Aviel". Comment: "If you took it too seriously, you're a babe"
6. Shir: Comment: "In my opinion, uniforms are not necessary because one must give to all children freedom to express themselves through clothes and also because I think that cloths are something personal. I don't think people should come with shirts that leave the belly out and also teachers shouldn't make comments on all what they think is not OK and on children who come with clothes that don't fit school"

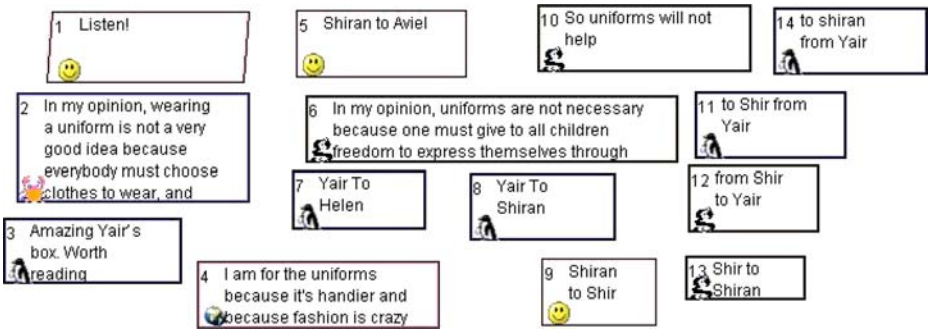


**Fig. 3** The map of Yair's group

7. Yair. Title: "Yair To Helen". Comment: "What? Uniforms? Don't be maniac! [Russian swearword] Go home and wear a uniform!
8. Yair. Title: "Yair To Shiran". Comment: "Great explanation"
9. Shiran. Title: "Shiran to Shir". Comment: "You're right!!!!!!!!!!!!!"
10. Shir: Comment: "So uniforms won't help"
11. Yair. Title: "To Shir from Yair". Comment: "Great explanation and I'm sorry people laughed at you. It was not on purpose!"
12. Shir: Title: "from Shir to Yair." Comment: "I didn't finish. I want to tell you that girls will choose the smallest size and except from that I don't think that the school will like it"
13. Shir: Title: "Shir to Shiran." Comment: "I know that I'm right but think who will come... there will be an uprising!"
14. Yair. Title: "To Shiran from Yair". Comment: "What a chutzpah. Why you don't answer, witch"

Contrary to Nitsan's group, the numbers do not represent any order in participation of the discussants but the chronological inscription of the messages automatically undertaken by the computer: discussants wrote their contribution, and meanwhile, other contributions were displayed although they often did not look at them during their writing. Although the instructions were that each one would first write down his or her own opinion without any reaction from the others, at the fifth turn, Shiran already interferes in this first round to tell Aviel "not to take it too seriously" (she probably refers to Aviel's comment that "people go to school to learn" [in turn 2]). This intervention forecasts the further hyper-personal interventions in the discussion. The title of the box is generally used to stress who is talking and often to whom (3, 5, 7, 8, 9, 11, 12, 13, 14) although this is not necessary since the colors of the boxes already point at their authors. The content of the messages convey mostly emotions. Some other interesting phenomena concern communication: (a) Parallel discussions: Discussants answer to two peers at the same time (in turns 6 and 7 for Yair, and in turns 12 and 13 for Shir); (b) Disrupted turn adjacency: A discussant (Yair) who complimented a peer (in turn 11) and does not get any immediate reaction, expresses his anger (in turn 14); (c) Interleaved exchange sequence: Scrutiny over timing for posting of interventions shows that while Shir writes her intervention (turn 10), Yair interrupts her to praise her (in turn 11); in turn 12, Shir finishes her previous intervention and at the same time directs it to the one who interrupted her. A last interesting phenomenon concerns "topic decay" (see above our review on synchronous CMC): from turn 7 on, when the

discussion is supposed to begin, discussants hardly elaborate new arguments, contrary to Nitsan's group interventions that developed as the discussion progressed. For example, Yair's interventions turn shorter and shorter. In his first personal intervention, Yair writes a claim ("I strongly oppose wearing uniform") and explanations for this claim ("they have a lot of other cloths" and "it's impossible to decide for people what to wear"). As the discussion develops, Yair's interventions become shorter, replete with chat-style expressions ranging from nicknames ("Amazing Yair") to swear words. Some references to peers' interventions are coded as other ("I'm sorry people laughed at you. It was not on purpose!"; "If you took it too seriously, you're a babe"; "Why don't you answer") and not productive in the sense that they don't bring new ideas to the discussion. In sum, this very short exchange is disrupted, uncovers a lack of coherence and does not progress. It contrasts with the discussion in Nitsan's group in which discussants built on their peers' previous interventions to elaborate new ideas relevant to the issue at stake.

Beyond the contrast between NN and OF cohorts, two interesting phenomena occurred for all groups. The first phenomenon concerns the fact that when groups of three to six students communicated in the computer laboratory, they sat in the same room and were invited to communicate through their PC but not verbally. The instructions were clear but students sometimes violated them. However, this violation that could have been problematic for the analysis of the experiment concerned technicalities only, not ideas about the issue at stake. Examples of typical oral interventions were "how do we ask for floor control?", "how do I see when my turn is?" or "Give up your turn, I saw that you finished your writing." This phenomenon suggests that the Digalo discussion at least does not hamper the emergence of ideas. It also appeared that students are quickly very fluent at using this channel of communication. The second phenomenon concerns organization of work in groups. We did not assign any role to the students. Interestingly, in each group, one student decided to organize the discussion: from the beginning, the number of shapes grew considerably on the screen and some shapes overlapped others. One student decided to organize the distribution of the shapes over the screen. For example he/she often said (orally) where to put shapes. This division of labor expressed collective willingness to share the same goal, engaging in a discussion about a social issue that was highly relevant to students, teachers and administrators in that school.

## Discussion

In the present study we examined effects of types of ontology and of synchronicity in students that engage intuitively, without training, in e-discussions. We tested the effects of using an informal ontology and control over turn taking on the average number of claims and arguments relevant to the issue at stake, the average number of (productive) references to peers, and on the number of chat expressions (nicknames, swear words, etc.). We found that when providing both an informal argumentative ontology and control over turn taking, students express less chat expressions and fewer references that are not new relevant claims or arguments to their peers, but express more relevant claims and arguments. These findings suggest the immediate beneficial role of the combination of an informal ontology and control over turn taking in the co-elaboration of knowledge.

The present study shows a very general result: the fact that the form and content in the co-elaboration of ideas is influenced by characteristics of the e-discussion tool through which argumentative activities occur. Taken as a general stance, this result is not new: it confirms the theory of representational guidance. The novelty, we believe, consists of

identifying the type of ontology and the type of synchronicity as characteristics of argumentative tools whose influence is decisive for the co-elaboration of knowledge[5]. The novelty also consists in the fact that although the measures we adopted to identify co-elaboration of knowledge—especially reference to peers with new relevant claims and arguments—were quite limited, they rendered visible what we could intuitively feel concerning the progression of graphical e-discussions. As for the type of ontology, again, findings are not totally new. Suthers (2003) already showed that providing an ontology in the scientific realm (including data, hypothesis, unspecified, consistency with, and inconsistency with) yields positive results. The novelty, however, resides in the fact that students used an informal ontology without any prior preparation to co-elaborate new knowledge. Adolescents have an intuitive knowledge about the use of language for reasoning. In face-to-face conversations, this intuitive knowledge is implicit. The presence of an informal ontology demands explicitness: Students need to decide on the function of their intervention in discussions. This decision invites students to reflect on categories that are understood to characterize co-elaboration of knowledge and yields the explicit elaboration of more relevant claims and arguments. Of course, the congruence between the choice of ontology and the content was often questionable. But students used 'support' and 'opposition' arrows, and "explanation," "argument," "claim," or even "else" categories to elaborate *their* ideas in front of the ideas of their peers or to co-elaborate ideas. We suggest that like the phenomenon of self-explaining (Chi et al. 1989), this explicitness enables deeper cognitive processing, involving meta-argumentative considerations. Although we did not compare here face-to-face and CMC discussions, we suggest that this is an interesting advantage of ontology based discussions. Another novel aspect that this study (especially the two examples) suggests: The fact that students very often referred to their peers points at another reason for the success of discussions with argumentative tools providing informal ontology. When typing their intervention in a map, students can see written accounts of the whole discussion held so far and can take them into account in their moves. Developmental psychologists such as Felton and Kuhn (2001) have shown that in face-to-face conversations, youngsters rarely refer to non-adjacent turns, as opposed to adults. Argumentative maps palliate this shortcoming, since all previous non-adjacent turns are visible to the discussant that often refers to previous non-adjacent turns.

The persistence of a textual record is common to all cohort conditions of the present study and explains the high number of references for all those cohorts. The nature of the reference was different, however, when an informal ontology was provided: it was more 'productive' in the sense that students referred to their peers with more new claims and arguments. Again, this difference can be explained by the fact that the categories provided to characterize each intervention invite students to refer to the topic at stake rather than to personal traits of the peer.

Concerning the second independent variable we studied, type of synchronicity (with or without floor control), it seems that floor control encouraged the expression of fewer references that we coded as 'other references to peers' in the sense that fewer references did not explicitly provide explicitly new claims or arguments to the discussion with floor control. Of course, as we could see in the two discussions above, decisions about coding references as "other" rather than "productive" relied on explicitness and some "other

[5] One may compare the present study with related work on social and epistemic scripts (see Weinberger et al. 2005): floor control can be identified as a kind of social script and ontology as an epistemic script. However, the two studies are partly comparable only, since the conditions under which students discussed are not expressed as explicit instructions but as technological constraints.

references" could have been seen as productive, especially in light of the way peers reacted to them. However, our claim is that FC afforded the elaboration of more references that make more ideas explicit, a fact, which is important. Theoretical consideration as well as the examples we provided suggest that different patterns of interactions are responsible for these differences. Without floor control, exchanges are often interleaved, and overlap. Although turn adjacency is often disrupted both with and without floor control, floor control confers an orderly character to discussions, and when having the floor one can react to all interventions expressed before.

The combination of floor control and ontology yielded by far the highest number of relevant claims, relevant arguments and productive references. This combination yielded the lowest number of chat-style expressions. We suggest that the FC function gave participants *time* to reflect and react and the ontology function gave a *tool* for reflection and reaction. In the analysis of the two discussions, our tracking of the temporal dimension of interactions was partial: To build a solid temporal argument, a fine-grained analysis of the interactions is needed. However, we think that this should be done in an additional study because of the difficulty of the enterprise. For example, adjacency and non-adjacency are quite tricky concepts in a synchronous FC mode of communication: if the request for a turn is submitted after a particular turn, but the discussant then has to wait, when she reacts to the turn she was originally responding to, she may have in mind all intermediary turns, even if she did not intend to. In the present paper we escaped this dilemma by tracing outcomes only. In certain cases, it may be possible to track intended adjacent reactions by looking at notebook. It may also be possible in certain cases to see how these intended reactions are edited by students during their waiting. But in other cases, it is impossible to discern between what was intended when submitting a request for a turn and what is actually inserted when the turn occurs, when for example students do not prepare their turns in notebooks. Regardless, the quantitative analysis suggests that our temporal-reflective is a reasonable working hypothesis that needs to be checked in further research.

When we articulated our hypotheses concerning the influence of floor control and of ontology, we anticipated the presence of chat-style expressions and that a lack of floor control would increase their number. Our approach was prospective though: although some research had been already initiated in this direction, a clear typology was missing; we decided to ground the identification of chat-style types of expressions on a categorization process. The hypothesis concerning whether chat-style expressions are beneficial or detrimental for co-elaboration of knowledge was unclear, and to some extent remains unclear. Of course, since more chat-style expressions came together with less relevant claims and arguments, we may be tempted to see chat-style expressions as detrimental for co-elaboration of knowledge. However, we should be cautious here. As already mentioned, discussants perceive synchronous CMC turn as more socially desirable; they allow hyper-personal expressions and a special conversational "feel" characterized by playful and humorous communication. When it comes to *co*-elaboration of knowledge, the real issue should be refocused to the conditions for which chat-style expressions are beneficial for co-elaboration of knowledge. The present study does not answer this question but helps understanding why the absence of floor control and ontology yields more chat-style expressions. When one participates in a synchronous discussion without floor control, she does not know whether it will be read or not by people and she may be very interested in their reaction; the other may be busy chatting with other students. It is more than natural to catch attention by using personal interjections or nicknames. If the other does not react, the discussant may try to interrupt him, again by catching attention through humor, swear words or personalized expressions. All these techniques convey the presence of the other.

This is particularly pronounced when, in addition to the absence of floor control, no ontology (especially no arrows of support or of opposition) are available. In contrast, when floor control is activated, discussants know that when they intervene, the others cannot. They are then more inclined to estimate that attention is ensured by this impossibility to interrupt. For this reason, the scarcity of chat-style expressions in synchronous communication with floor control resembles the 'filtered' character observed by researchers in asynchronous communication.

Although the present study concerned elaboration of knowledge in the course of e-discussions, the issue of middle-term learning effects of discussions is also important. In the present study we planned to tackle this issue by checking whether individual (written) arguments actually improved as a result of the e-discussions. However, students refused to cooperate in the last stage of the original plan of the experiment (many argued that they already wrote their arguments in the maps). This further learning should be investigated.

We focused on the intuitive use of informal ontology in CMC. We have shown that with tools like Digalo, students have a natural propensity to engage in discussions without any training. The issue of the role of training in the use of informal ontology in e-discussions is separate. And indeed, Pilkington and Walker (2003) have shown that although the use of chat channels leads in first meetings to undesirable outcomes, this tendency diminishes over time; discussions that are first not focused on the topic are gradually more focused and less disrupted. Students become more responsive to each other's contribution, and more adept at making, backing and challenging arguments. Pilkington and Walker have noticed a possible reason for this gradual change: "...with Chat tools students over time "created a more inclusive and 'safer' learning culture in which children were less likely to be berated and more likely to be validated and encouraged to participate" (p. 172). The differences we discerned in initial stages of the use of Digalo may then diminish later on. We nevertheless hypothesize that for specific goals related to co-elaboration of knowledge, the tendencies we identified would persist. Regardless, questions such as 'what happens after a long period if students exclusively interact without floor control versus with floor control?' are perhaps not the best to ask. Rather, it seems more adequate to ask when to encourage different kinds of practices such as e-discussions with or without FC. The pioneering studies on the benefits of the use of argumentative graphical tools in middle- or long-term experiments (Muller Mirza et al. 2007; Schellens et al. 2007; Schwarz and de Groot 2007) suggest a pluralistic approach to the implementation of practices. It seems reasonable that for learning specific knowledge, floor control is preferable, but for 'learning to learn' (e.g., learning to summarize a critical discussion) or for learning to collaborate, floor control may be detrimental in the long run. Also, even when the aim is to learn specific knowledge, e-discussion maps without FC may be beneficial at a first stage of brainstorming to make public students' (intuitive) knowledge in order to initiate further e-discussions.

We did not focus on the role of what we called 'educated ontologies' on the elaboration of scientific knowledge. The use of discussion based tools for the acquisition of scientific knowledge is a new domain in which several researchers (e.g., Bell and Linn 2000; Sandoval 2003) designed environments to structure students' knowledge representations and discussions. We suggest that the approach we adopted here to identify variables that influence the design of the environment should be adopted in this new domain.

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