Hever, R. (2008). A holistic, bottom-up approach to identifying collaborative argumentation clusters in Digalo discussions. Unpublished seminary paper, based on work by Hever & Gil.

Abstract

The importance of discussion and collaboration to learning processes, and the role of technological tools in this context, are issues which have long been recognized in CSCL literature. Our aim in this essay is to suggest a methodology to support the analysis of interaction patterns as they arise from the use of such a tool, and to examine the results of its application in light of theories and phenomena related to interactive learning processes. An innovative methodology for analysis and evaluation of collaborative learning within the framework of a synchronous, graphic environment – the Digalo tool – is created and validated. Six types of interactive "clusters" (interconnected discussion contributions) are found, characterized and discussed in light of theoretical concepts related to the effects of counter-argumentation, shared construction of knowledge, intersubjectivity and more. Specifically, we ask whether there is a dialogic effect on knowledge construction, and if so, in what manner it is expressed. Furthermore, we discuss the characteristics an analysis method should have in order to capture such processes, and the specific advantages and limitations of the methodology presented herein for this purpose. Finally, we describe the prospective challenges this methodology faces.

Introduction

The importance of discussion and collaboration to cognitive and social development has long been recognized in the field of CSCL. Many tools have been developed in order to support and promote more efficient learning processes and practices, e.g., CSILE (Scardamalia & Bereiter, 1994), Belvedere (Suthers, 2003) and CoolModes (Wichmann, Kuhn, & Hoppe, 2006). Surprisingly, although the design of such tools is often well rooted in theory (e.g., collaborative learning or argumentation theory), studies that trace their efficiency in practice are not common. Our aim in this essay is to suggest a methodology to support the analysis of interaction patterns as they arise from the use of such a tool, and to examine the results of its application in light of theories and phenomena related to interactive learning processes.

The collaborative tool we focus on is Digalo[1] – a graphical, synchronous e-discussion tool (Schwarz & Glassner, 2007). The tool may be used to map knowledge in an argumentative structure (or any other type of concept mapping) collaboratively or individually, but more than that, it serves as an internet-based synchronous discussion tool, which displays the organic flow of discussion and argumentation in addition to the static representation of constructed knowledge.

The Digalo tool uses a space called a "map", in which discussions are held (see Figure 1). Users contribute to the discussion by adding shapes representing argumentative ontology (e.g., rectangle for claims, circle for explanations) and typing their text into them. Typically a user would type a short text as the title of the shape (text visible in the map), and then elaborate further in the "comment" slot (visible when shape is clicked open or via a tooltip when the mouse hovers over the shape). Each shape

[1] This tool was developed within the framework of the EC-funded DUNES project (IST 2001-341653, http://www.dunes.gr/).

contribution is marked with an icon, which represents the contributing user, and a number, which represents its sequential order. Users may also link shapes to other shapes, using arrows of different types (support, opposition, [neutral] reference). All actions within this space (e.g., create/edit/delete/move actions on shapes and arrows) are logged, and these logs may be exported and viewed as EXCEL tables or XML files.

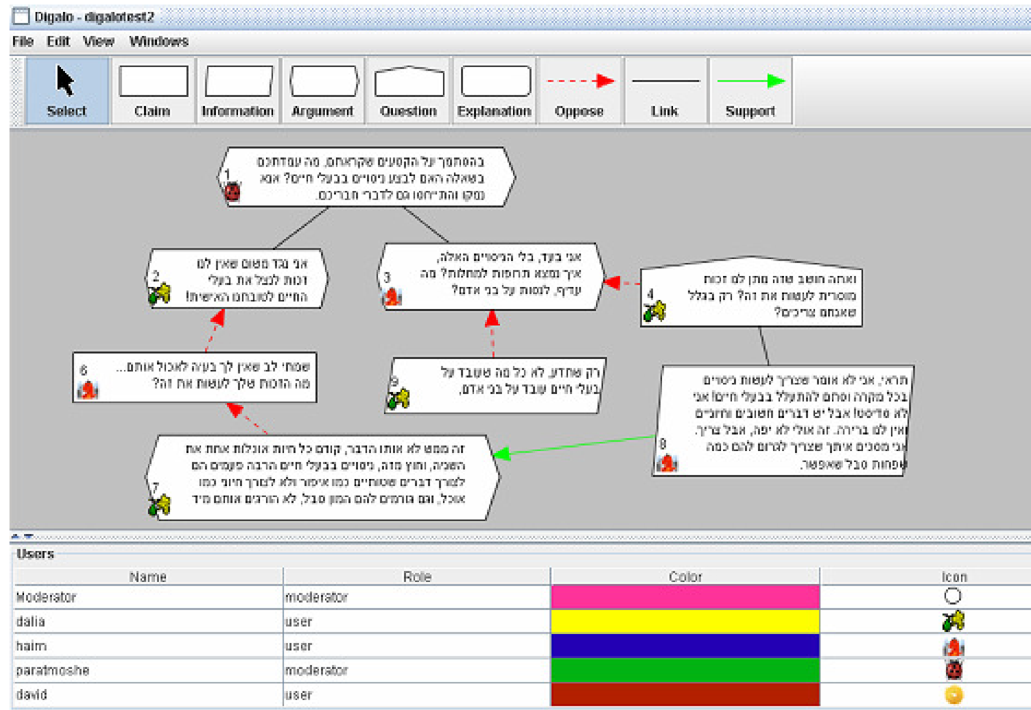

Figure 1: A Digalo map example (created using Digalo v.2)

The use of Digalo has become more widespread in recent years (currently at several schools and universities in Israel, France, Colombia, the Netherlands, Switzerland and the UK, see also Schwarz & Perret-Clermont, 2008), leading to increasing research and evaluation efforts. Digalo discussion outcomes (maps and/or log files) have previously been analyzed in different contexts, with different goals in mind and using different methods. These attempts are briefly described in the following paragraphs[2].

The first attempt to create and validate a methodology for analysis and evaluation of learning in interaction in the context of the Digalo environment was that of Lotan-Kochan (2005, 2006). The first step in this effort was to comprehensively review existing analysis methods and evaluation tools used in the context of both argumentation and computer-supported discussions. Upon completing this review, Lotan-Kochan found neither of these methods to be fully compatible with the special affordances of the Digalo tool, the characteristics of educational discussions that it promotes, and a research and pedagogy agenda that emphasizes the collaborative

[2] The literature review in the introduction section will focus specifically on methodologies that have been applied to the analysis of Digalo maps and will be as succinct as possible. Other research efforts relevant to the analysis and evaluation of peer argumentation and educational discourse are elaborated on – in much greater detail – in the discussion section, after the reader has become familiar with the methodology and the specific typology findings. In light of the preliminary and exploratory nature of the methodology used in this paper, I believe it to be a reasonable allocation.

construction of knowledge[3] (cf. Schwarz & De Groot, 2007). Integrating and adapting elements from several approaches, Lotan-Kochan (2005) created a unique evaluation tool for assessing the quality of Digalo discussion maps, focusing on aspects of argumentation, interaction and concept learning. Within her framework, each aspect is measured through a set of different criteria (e.g., number of arguments, depth of arguments, focus), pertaining to different levels of granularity (namely the level of an individual shape, the level of inter-personal communication and the inter-subjective level). This evaluation tool was examined through a comparative analysis of maps created with and without the support of a teacher. The assumption was that the tool will be able to reveal higher outcomes for the groups that received teacher mediation, at least for some of the evaluation criteria. While no statistically-significant differences were found between the intervention and control groups in Lotan-Kochan's study, and while the process of evaluation according to all the criteria proved to be long and effort-intensive, some of the criteria suggested may be used individually or in sets to evaluate particular aspects according to the goals of the teacher or researcher.

De Laat, Chamrada and Wegerif (2008), in an attempt to create a Digalo map evaluation tool for research purposes (under the umbrella of the Argunaut project, about which I will elaborate further below), used a similarly complex coding scheme. Their scheme included multiple levels (contribution, sequence of contributions, and the entire discussion map) and multiple dimensions (group dynamics, critical reasoning, dialogic reasoning, dialogic engagement, and moderation). They've further attempted to develop a coding methodology that can show some kind of continuum between these levels (e.g., where the coding on shape level will inform the coding on a sequence or even a map level). A crucial step in this type of analysis had to do with determining the individual discussion threads within the map, in order to locate sequences related to the emergence of critical dialogic moments in a discussion. A sequence, as defined by De Laat, Chamrada and Wegerif (2008) is "a continuous thread of dialogue in which all messages are linked together by their content" (and not necessarily by graphical arrows in the map). De Laat and his colleagues focused on two types of such sequences, which they termed '*widening*' and '*deepening*'. *Widening* moves represent attempts to "break away" from a particular perspective by either questioning it or presenting a new perspective. *Deepening* moves, on the other hand, provide further argumentation for a perspective that is being discussed at the time.

Unlike Lotan-Kochan (2005, 2006) and De Laat, Chamrada and Wegerif (2008), who attempted to encompass all relevant aspects and granularity levels in their analyses, Muller Mirza, Tartas, Perret-Clermont and de Pietro (2007) focused on the analysis of interaction rather than the structure of argument. Guided by their educational goals (learning about the debate from argumentation, rather than learning to argue), their approach to analysis was bi-focal: on the one hand, attempting to trace the emergence of historical understanding (content area knowledge) within the discussion, and on the other hand, treating argumentation as a social activity[4] (interaction analysis). In order to explore the latter focus, Muller Mirza and her colleagues used Leitão's model

[3] Such as the agenda of the Kishurim Group, led by Prof. Baruch Schwarz of the Hebrew University of Jerusalem, a member of which she was at the time (as I am at the moment).
[4] The approach explored in this paper shares this focus on the interactional view of argumentation, if not the other (of content-area knowledge).

(2000) for analyzing counter-argumentation and its effects on the discussion. Following Leitão, they applied the terminology of *argument*, *counter-argument*, and *reply* to sequences of interaction within Digalo maps. Leitão's model and the findings of Muller Mirza and her colleagues are elaborated further in the discussion section of this paper.

The approaches described above (with the possible exception of the work on sequencing from De Laat and colleagues, 2008) are aimed at post-discussion evaluation of Digalo maps. Their application to the analysis of Digalo maps requires time, effort and expertise. While they may be useful for research purposes, they are far too complex and time consuming to be used on a wide scale by, say, teachers wishing to evaluate the work of their students.

The EC-funded Argunaut project (IST-2005-027728, http://www.argunaut.org) aims at providing **teachers** (and other potential moderators of e-discussions) with computerized tools that will help them evaluate **ongoing** Digalo discussions (the **process**) as well as "completed" discussion maps (the **product**, as it were). For this purpose, several approaches have been undertaken towards using both "shallow" computational methods and "deeper", AI-based methods in order to promote real-time analysis of ongoing Digalo discussions (Hever, et al., 2007; De Laat, Chamrada, & Wegerif, 2008; Hoppe, et al., 2008; McLaren et al., 2008; Harrer, Hever, & Ziebarth, 2007; Harrer, Ziebarth, Giemza, & Hoppe, 2008; Miksatko & McLaren, 2008; Scheuer & McLaren, 2008). The work presented in this paper and the sequencing work done by De Laat, Chamrada and Wegerif (2008) represent the most recent of these approaches. The remainder of the introduction will be dedicated to a brief survey of the other approaches and their results, followed by a description of the current paper's approach (from both a theoretical and goal-oriented perspective).

The Argunaut system (a complete description thereof may be found in Hoppe, et al., 2008) incorporates several tools: the Paseo tool (for user and data management), the Digalo discussion tool (mentioned above), the FreeStyler e-discussion and e-collaboration tool and a unique tool called the Moderator's Interface, which was unifies functions of awareness (i.e. representations of important aspects in the discussion) and functions of remote intervention. The specific indicators and visualizations chosen to represent the relevant aspects per discussion were carefully co-designed in a collaborative process involving pedagogical researchers, technological experts and teachers (Hoppe, De Groot, & Hever, in press).

Some of these awareness indicators, for example "user activity[5]" and "ontology use[6]", are considered "shallow", since they are the products of simple computational processes. The Argunaut project members additionally used a variety of more sophisticated techniques in order to produce awareness indicators that combine structural and process-oriented elements (e.g., types of connectors, user actions) with textual elements (discussion content). Such indicators were presumed to be the first step in highlighting more pedagogically meaningful aspects of the discussion (e.g., critical thinking, dialogism).

[5] A histogram graph showing the distribution of different logfile-level actions in the discussion environment, per user.

[6] Pie-chart graphs showing the distribution of shape types and arrow types in a Digalo map.

One approach aimed at achieving this goal was to train machine-learning classifiers to classify discussion units (shapes and paired-shapes) into pre-defined theoretical categories (e.g., topic focus, claim+backing, request for more information), using structural and process-oriented attributes (and, for English-language maps, additional linguistic cues). The classifiers were trained with examples categorized by pedagogical researchers, based on content and some contextual cues (McLaren, et al., 2007). Several of these classifiers were integrated into the Argunaut system via a webservice that provides interested moderators with alerts when shapes and paired-shapes in the discussion match the relevant categories (Scheuer & McLaren, 2008; Hoppe, et al., 2008).

A second approach to the automation of search for meaningful phenomena in the discussion was the use of a pattern matching tool in conjunction with e-discussion XML log files to generate "rules" that find "patterns" combining user actions (e.g., create shape, delete link) and structural elements with content keywords (Harrer, Hever, & Ziebarth, 2007, see examples there). This approach proved less successful, due to the complexity and variability of action patterns and the syntactic limitation of the specific pattern matching tool used.

In general, it may be said regarding these approaches that, although individual contributions were evaluated (shape-level classification), presence of backings was sought for and viewed as a quality measure, and patterns related to the behavior of the individual were defined, the theoretical focus was greatly influenced by the shift towards dialogism in the context of critical reasoning (Schwarz & De Groot, 2007). This is reflected in the search for dialogic aspects, even at the granularity level of single contributions (e.g., request for more information), in the attempt to characterize relationships between pairs of shapes (the minimal unit of interaction[7]) and in the attempt to define larger patterns of interaction and collaboration (e.g., chain of agreement).

The view of argumentation as a dialogic, social process is a view shared by both developers of the methodology presented within – Mrs. Julia Gil and I. As members of the Kishurim Group, we seek to promote reasoning and to instill in students “norms and values compatible with a philosophy of dialogue” (Schwarz & De Groot, 2007, p. 299). These are also the pedagogical principles we see as important in the context of using Digalo.

The methodology presented here therefore focuses on the dialogic and collaborative aspects of knowledge construction and argumentation. The assumption is that the appropriate level of analysis for revealing and studying relevant processes is the micro-genetic level. For this reason, the current analysis attempts to characterize interactive structures appearing in Digalo maps, taking an exploratory, holistic approach. That is to say, when looking at "clusters" (i.e. semantic units of interlinked shapes) the idea is not to break them down into components and try to characterize each component, but rather to come up with a typology of such clusters, as it occurs in the organic context of the classroom discussion via the Digalo tool. We recognize that

[7] I will return with a critical eye to the notion of paired-shapes as the minimal interaction unit, see the ‘methodological considerations’ section in the discussion.

the same phenomenon may be expressed in different forms (e.g. different number of shapes, different shape ontology and link types, different interlinking patterns, etc.), though it may be regulated by the same underlying principles.

The phenomena this methodology seeks to uncover are related to the patterns of discussion which exemplify how collaborative argumentation occurs, how people create an argument together, through the process of discussion. In this context, processes by which input from others leads to improved reasoning (e.g. clarifying a position, providing more information, giving reasons) are stressed, while the individual's construction of knowledge or the “formal” evaluation of argument quality (e.g., according to Toulminian models) are not.

The clustering methodology and resultant cluster typology are aimed at serving the following purposes:

(1) To be used as a fairly quick and simple method of evaluating Digalo discussions in a meaningful way, by either researchers or teachers;
(2) To be used in the context of the Argunaut system, in conjunction with innovative AI methods such as Query-By-Example (QBE, see Miksatko & McLaren, 2008), in order to identify important clusters on-the-fly and support the e-moderation of Digalo discussions.

The remainder of this paper will be dedicated to describing and discussing this methodology and the initial typology of clusters that it produced.

Method

As mentioned above, this essay presents some preliminary findings and examples derived from an exploratory attempt to create a typology of discussion "clusters" (semantic units of interlinked shapes) in the specific context of the Digalo discussion environment. This attempt was primarily a bottom-up process, locating in a set of existing Digalo maps groupings of shapes which could be considered as representing interesting, important or problematic phenomena, then naming and characterizing recurring patterns. The focus of this search was on patterns of discussion which show elements of collaborative argumentation.

In the first phase, two researchers, Mrs. Gil and I, worked together, searching for patterns (primarily guided by Mrs. Gil’s insights and rich pedagogical experience), negotiating definitions for them and discussing disagreements regarding specific ‘hits’ (i.e., whether they match a certain cluster type) until they were resolved. The process is more fully elaborated below.

Initially, twenty one Digalo maps were examined. These maps are the products of actual high-school e-discussions on the topics of biology, genetics, physics, literature and psychology, all originally in Hebrew. In seven of these maps, perhaps due to the nature of the questions put for discussion and/or the teachers' instructions, the students did not use the affordances of the discussion tool as intended. They wrote brief,

superficial content in their shapes (immediately apparent), barely linked between their contributions and/or used the tool to write essay-like answers to the teacher's question[8]. In light of this, we excluded these maps from the set, so that in the first phase, the full search was performed for only fourteen maps.

Each of these remaining discussion map files was separately opened in Digalo. Each contribution was read fully, and the patterns of interlinking were examined. When a noteworthy type of cluster was initially identified (based on the theoretical approach described above and the pedagogical experience of the second author), the map name and shape numbers were recorded along with an initial description of both its semantic and structural characteristics (serving as cues and strategies for locating and identifying further examples, rather than formal definitions). It should be noted that, while the search was loosely cued by structural hints (e.g. structurally interlinked shapes are more likely to form a cluster in which the shapes are also thematically linked; presence of opposition links is a strong indicator of disagreement, etc.), the type of cluster was defined primarily according to discussion content within the shapes. This pool of cluster types was refined as more instances of similar phenomena were found and examples were added. After the first round was complete, all maps were examined a second time, with the full set of cluster types in mind, to make sure no examples were missed. Throughout this process, as mentioned above, any disagreements were resolved by discussion (often leading to further refinement of the cluster type definitions).

In the second phase of analysis, I worked alone, searching for further examples of similar clusters in a second set of twenty five Digalo maps[9], revolving around various subjects (typically social, political, historical or educational dilemmas, sometimes around a scientific issue, e.g., should cloning be allowed). As in the previous set, all these discussions were originally in Hebrew, and were the products of classroom activities integral to the students' curriculum). The search for examples in this second phase focused on three of the simpler cluster types (structurally-speaking) found in the first phase. This was done with a view to possible automation of the clustering process in the future, using Query By Example (QBE) AI methods (Miksatko & McLaren, 2008). Although the search in the second phase was focused on the three cluster types that were the most viable candidates for use with QBE methods, I made a note of "new" interesting phenomena when I came across such examples that, in my view, could also serve as potential candidates for the same purpose[10].

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[8] Five of these maps were maps revolving around a comparative analysis of two poems on a similar subject. The literature teacher's instructions did not seem to stress the **dialogic** element of the tool enough, since the children primarily used it to write their own, extremely long and integrative answers to the teacher's question, with almost no reference in either of the maps to contributions from others. The other two maps both revolved around the same question in the field of psychology, attempting to offer an answer to the question of what psychological phenomenon played part in an incident described in the teacher's question. At a cursory glance, there did not appear to be much argumentative content to these maps, with the students' answers being fairly brief and superficial, not using the ontology of links in an optimal way, etc.

[9] The original set numbered thirty one maps, but six of them were excluded due to various reasons: almost no linking, specific organization of the map according to unknown principle, extremely brief content in shapes, and barely any contributions.

[10] I found four such cluster types. However, the maximum frequency of neither exceeded 2, so these results were discounted (and will not be reported below).

Preliminary findings and cluster examples

The initial search for cluster types yielded six types of relevant clusters[11]: shared reasoning including argument and counter-argument, clarification of opinion following feedback, different backings for the same claim, chain of opposition, argument + evaluation, and summary, conclusions and/or decisions. The frequencies of cluster examples of each type as found in the map sets used in both sets of the process can be seen in Table 1 (extremely 'borderline' cases not included in the count). These frequencies are presented merely for indicatory purposes, since this research is not quantitative by nature[12]. It should also be noted that the cluster type labels are not mutually exclusive – "chain of opposition" sequences could also be counted as "clarification following feedback" sequences on several occasions. Similarly, it was not uncommon to find smaller cluster patterns (e.g., "chain of opposition", "argument + evaluation") in larger patterns (e.g., "shared reasoning including argument and counter-argument").

Table 1. Frequencies of clusters per type in two sets of Digalo maps

Cluster/Frequency	1st phase (14 maps of an original set of 21)	2nd phase (25 maps of an original set of 31)
Shared reasoning including argument and counter-argument	5	N.A.
Clarification of opinion following feedback	4	20
Different backings for the same claim	6	N.A.
Chain of opposition	8	25
Argument + evaluation	5	26[13]
Summary, conclusions and/or decisions	5	N.A.

This section will elaborate on the cluster types found (in the first phase) and illustrate them with some examples from Digalo maps[14].

1. *Shared reasoning including argument and counter-argument*

Clusters of this type involve three or more users and must contain both an argument and a counter-argument. Furthermore, there should be some indication that this reasoning is shared, that the discussants are listening to each other and building on each other's arguments, not just stating their own opinions or dismissing those of

[11] Another type of cluster was "social presence", which includes off-topic, non-argumentative content, and therefore is less relevant here.
[12] Additionally, the frequencies for the second set represent only my own personal judgment. Unsystematic (as yet) attempts to validate them by means of inter-rater reliability measures have so far yielded poor to mediocre results (depending on the cluster type). Cf. the discussion section of this paper.
[13] It should be noted that for this cell in the table, the proportion of 'borderline' examples was considerable, and points to the problematic nature of this element in the coding scheme.
[14] Please note that for all figures, only contribution "titles" are displayed in the map. In many cases the contribution continues in the "comment" slot, and will be separately elaborated if needed.

others with counter-arguments. These structural cues characterizing this type of interaction are a medium-large cluster size (cluster examples found so far range in size from 4 to 9 shapes per cluster) and the presence of more than one type of arrow (e.g., if all arrows are of the "support" type, we are not likely to find this type of reasoning in the cluster). The cluster examples found for this type vary quite considerably, in terms of number of shapes involved, number and types of links involved, interlinking patterns and overall shape.

A couple of good examples for this type of cluster can be seen in Figure 2 and Figure 3 below (relevant clusters surrounded by a blue line, opposition arrows highlighted in red, support arrows highlighted in green). Both these discussions revolved around the same question, and were held in the same classroom by different groups. The students, having previously read two articles about experiments on animals, were required to state their opinion on the subject, to back it up with reasons and examples, and to respond to two arguments written by others. Despite the similar context, the linking types and patterns are visibly different in the cluster examples from both maps. For example, in the shared reasoning cluster in Figure 2, we see only opposition arrows and neutral links, while the cluster in Figure 3 also contains support links.

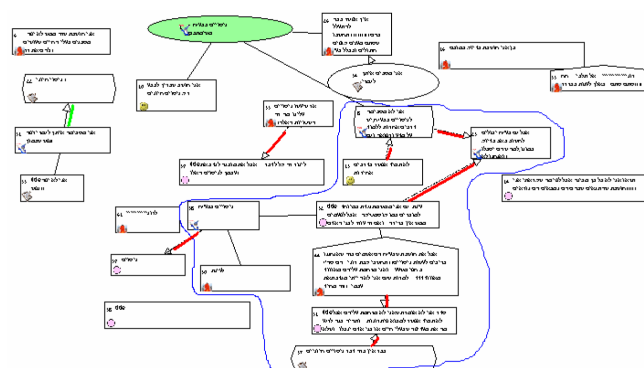

Figure 2: A "shared reasoning…" cluster example from a discussion titled "biology_experiments3"

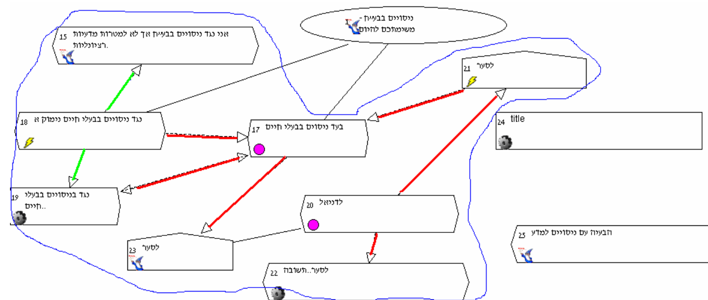

Figure 3: A "shared reasoning…" cluster example from a discussion titled "biology_experiments7"

As indicated above, structural elements such as arrow types and linking patterns are not enough to determine the cluster type, and serve merely as cues. What is truly interesting is the content of the contributions and how the discussants relate to each other. Examples of this can be seen in Table 2, which displays the content of the shapes shown in Figure 2. For each contribution, the table shows the name of contributor, the shape number, the text and connections to other contributions. Although there is quite a lot of disagreement (some students are in favor of performing experiments on animals and some are against it), opposing opinions aren't

ignored or dismissed, and opponents aren't attacked. Rather, the students appear to try sharing points of view and points of agreement even as they are disagreeing (see for example Table 2, shapes 32, 44, and 41).

Looking at the sub-cluster of shapes 8, 15, 25, 32 and 38 (see Table 2 below), will illustrate how the argument evolves and opinions are elaborated as a result of counter-arguments raised. In contribution 8, Einat argues against experiments on animals, stating two reasons: availability of other methods of study and problems in generalizing from animal experiments to humans. Dor replies with contribution 15, addressing her first reason and stating that there aren't always other alternatives. In response to this, Einat brings up another argument in shape 25, regarding the moral aspect of animal experiments, which should apply even in cases where there aren't other alternatives. Roni joins the thread with contribution 32 with conditional agreement which can perhaps be seen as some kind of compromise. She says that while she agrees with Einat and is against experiments on animals, "especially when it comes to products like cosmetics," there are cases in which "there isn't really any other choice". She also addresses the moral aspect by saying that animals should be kept in better conditions and that experiments should be as humane as possible. Einat then picks up on these two points and elaborates further about experimentation related to cosmetics and the conditions in which the animals are kept, with a repetition of her second argument in contribution #8, which has not been refuted (i.e. that drugs don't necessarily affect humans and animals the same way).

Table 2: A tabular representation of the cluster shown in Figure 2

Discussant name	**Contribution/ shape number**	**Text of contribution (translated from the original Hebrew), "title" and "comment" combined**	**Connected to contribution number… (+ link type)**
Einat	8	I am against experiments on animals, there are other ways to study science and medicine, as well as most drugs that affect animals do not affect humans the same way	#1 (neutral) #15 (opposition) #25 (opposition)
Dor	15	There aren't always other alternatives	#8 (opposition)
Einat	25	But animals can feel pain just like us, why should they suffer while we do not?	#8 (opposition) #32 (opposition)
Roni	32	Einat... I am also extremely against especially when it comes to products like cosmetics... but sometimes there isn't really any other choice... and if it helps humans then I have no choice and I have to agree to experiments, but the conditions under which animals are kept are terrible and it could be done in a more humanistic way	#25 (opposition) #38 (neutral) #44 (neutral)
Einat	38	Experiments on animals: I am extremely against the experiments. There are other ways to study drugs/medicines, and the experiments for cosmetics are unnecessary, one shouldn't kill an animal for a shampoo. The conditions under which the animals are	#32 (neutral) #50 (neutral) #59 (opposition, neutral)

		kept - are shameful. Imagine someone took you from your family, stuck you in a cage with many other humans and without food, and you had to lick the cage's bars to get some iron? Except that as we saw, not all experiments that affect animals - will affect humans the same way.	
Linor	44	But do you think animals should "pay" because we need to make experiments?! Think about it Roni... they are innocent after all... and I feel pity for them so much.... although I also wouldn't volunteer for experimentation..!! It is scary...	#32 (opposition) #51 (neutral)
Linor	50	To Einat: I agree with you for 100% that there shouldn't be any experimentations for cosmetics	#38 (neutral)
Roni	51	OK. I'm not saying I don't feel pity for them but you can't always find [other] solutions... And be honest for a moment, what do you prefer, to have animals or humans saved... And don't misunderstand me, I really disagree [with experiments on animals] but to be honest I prefer for humans to be saved... and I am definitely against the conditions [under which animals are kept]!!!	#44 (opposition) #57 (opposition)
Joseph	57	There aren't any essential experiments anymore. There is no need for it 'cause scientists already discovered everything they could find about using animals. All the future discoveries can be achieved without laboratory animals. and to my opinion now they are torching them just for money (yes they get money for that)	#51 (opposition)

2. *Clarification of opinion following feedback*

These are typically small clusters, usually simple tri-shape chains where two of the shapes are by the same user. The repeated pattern for this type of cluster is a discussion contribution (shape) by person A; followed by a contribution by person B (linked to the first contribution from person A by an arrow) and then a third shape with a reply from person A (either linked to the first contribution or to person B's contribution). This reply has some sort of clarification of person A's opinion, what he or she tried to express in the previous contribution, etcetera. The examples found for this type of cluster may differ in the type of arrows between shapes and in the particular linking pattern, but overall are quite similar in terms of structure (when compared with shared reasoning clusters). Since this is a repeating pattern with fairly fixed structural aspects, the definition and search for this cluster type relied heavily on structural cues.

Figure 4 and Figure 5 show two different examples for the "clarification of opinion following feedback" type of cluster. The examples are taken from discussions on

different subjects (experiments on animals and a dilemma of whether to give a sick child antibiotics in a certain scenario), in different classrooms (the former in a high-school and the latter in a teacher training course at a college).

The first example, shown in Figure 4, can be seen as a sub-cluster of the shared reasoning cluster shown in Figure 2 (see also Table 2 above for the text of contributions 32, 44 and 51 in this cluster). In response to Roni declaring that "…if it helps humans then I have no choice and I have to agree to experiments", Linor asks why animals should suffer to help humans, and mentions that she feels pity for them. Roni replies with a clarification: she does feel pity for the animals, is against unnecessary experiments and the conditions in which animals are kept, but when it comes to a choice between saving humans and animals, she'll choose to save humans. In this case, the clarification comes in response to a counter-argument, and is linked to it by an opposition link (i.e., also answers the criteria for a “chain of opposition”, as do several other examples for this cluster type).

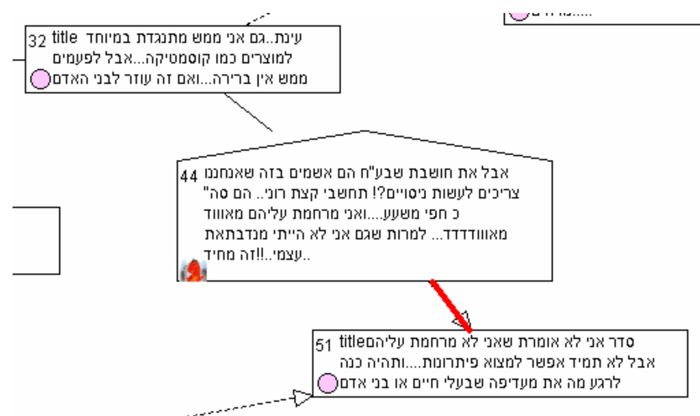

Figure 4: A "clarification of opinion following feedback" cluster example from a discussion titled "biology_experiments3"

In the example shown in Figure 5, the clarification is in response to a direct question requesting information. The discussant Jamal stated that "13 thousand patients in the USA died in 1992 from infections caused by resistant bacteria." This prompted a question from Mahmoud: "Was the cause of death only because of bacteria resistance?" Jamal replied with a clarification: "According to the article it was the reason of death. Resistance alone." This request from Mahmoud pushed Jamal to clarify the context of his statement and its relevance to the discussion: it brings further support to one of the arguments raised in the discussion, that antibiotics should not be given when cause of disease is not sure, because over-use of antibiotics has led to the development of resistant bacteria (elaborated further in other contributions).

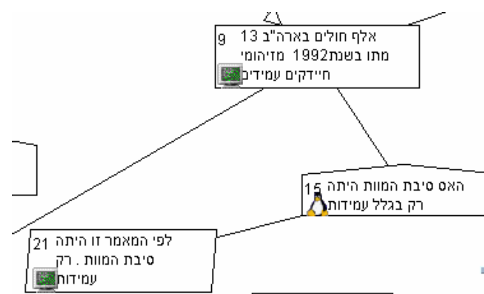

Figure 5: A "clarification of opinion following feedback" cluster example from a discussion titled "0grup1"

3. *Different backings for the same claim*

Clusters of this type must contain at least two different backings for the same claim, opinion or argument, given by two different people who link their contributions to each other either by a direct or indirect arrow, or by specific reference to each other in the text of their contributions. This could be a sub-cluster in a larger cluster of shared reasoning, for example. Support arrows between contributions can provide some indication of where to look for, although arrows do not always appear between these shapes directly, and it should be checked that both contain some kind of backing, not merely a statement of agreement (e.g., "I agree").

Figure 6 shows an example of such a cluster, where the three contributions circled with a blue line elaborate different reasons for an argument against experimenting on animals. Note that shapes 11 and 14, which are also linked to shapes in this cluster with support links, contain only statements of agreement (without any backing), and were therefore not included.

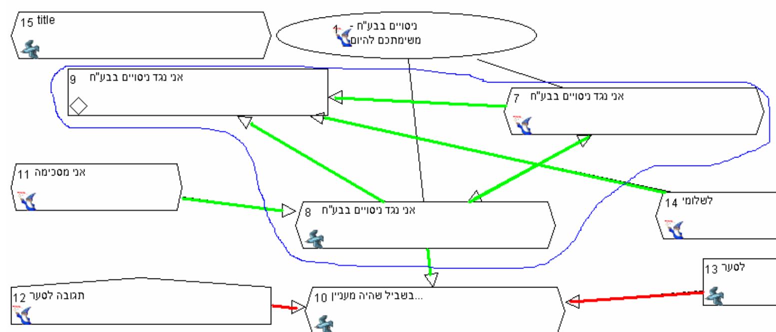

Figure 6: A "different backings for the same claim" cluster example from a map titled "biology_experiments8"

4. *Chain of opposition*

Typically these are linear chains (sequences), smaller than "shared reasoning" clusters (can be sub-clusters inside them), with two people "ping-ponging", arguing back and forth, each time raising counter-arguments to each other's opinion. The minimal pattern is of three shapes from two different users, similar to "clarification of opinion following feedback" clusters described above. However, although these two cluster types aren't mutually exclusive, the chains of opposition are quite often longer (4-6 shapes) and some expression of disagreement (either with opposition links or text content) is a requirement. To be included in this type of cluster, each reply in the chain should contain some backing (even if it is of poor quality) and not merely a statement of opposition to the previous one (e.g., a reason, an example, some evidence, etc.).

Examples for this type of cluster can be seen in Figure 7 (two examples from a discussion about whether to abort a fetus that has a high chance to develop CF disease) and in Figure 8 (from a discussion about cloning). The students who created the map depicted in Figure 7 also used the option provided by Digalo to change the background of their contribution shapes from white to a color of their choice. In this case, they chose red as a background color for those who are in favor of abortion for

the CF fetus, and pink for those who are against. The two chains depicted clearly show opposition links between shapes. In the example shown in Figure 8, the links between the shapes are neutral, although the discussants are clearly opposing each other:

> Achiav (contribution #14): "Life is the most supreme value and cloning can save life so why isn't cloning justified as long as it saves lives?"
> Anat (contribution #21): "Because cloning no matter for what purpose is still cloning."
> Achiav (contribution #22): "Is it preferable to keep 'morality' and not save human life? Isn't the mere fact of not saving life while we have the opportunity to do so immoral?"
> Anat (contribution #26): "That's a good point but the fact is that the government prohibits any kind of cloning."

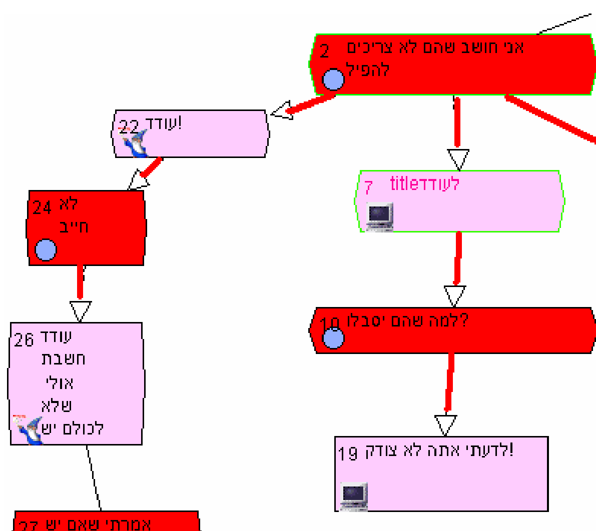

Figure 7: Two "chain of opposition" cluster example from a map titled "genetics_cf3"

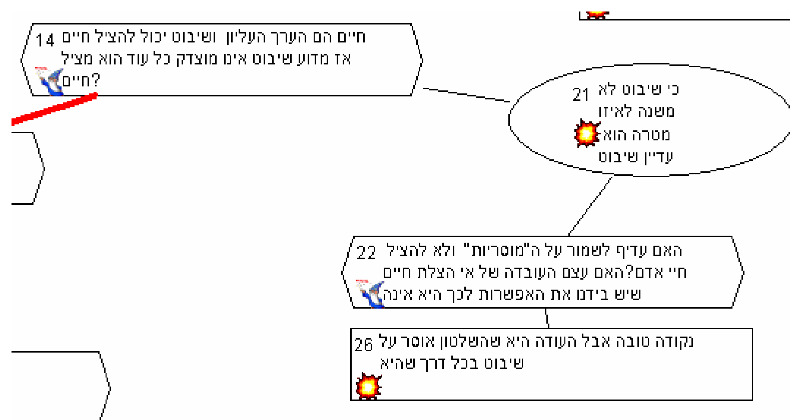

Figure 8: A "chain of opposition" cluster example from a map titled "clonning7"

5. *Argument + evaluation*

This type of cluster must include fairly strong and explicit evidence of a discussant evaluating the argument of another discussant. It should be noted that it is relatively hard to make the judgment in this case, and that many "borderline" cases were found. Typically these are smaller clusters (can be just shape pairs), which may be part of larger clusters of different types (e.g., a chain of opposition cluster can contain a sub-chain in which one of the discussant evaluates the argument of another).

An example for this type of cluster can be seen in Figure 9, taken from a map discussing experiments on animals. A discussant named Yuval elaborates an argument on why experiments on animals should not be undertaken, giving several reasons and examples and emphasizing cruelty towards the animals (contribution #18). A discussant named Elad responds (in contribution #21, titled "it's not good to be an extremist"): "Your opinion is partly correct. Indeed, there are some experiments that hurt animals and are very cruel, and are not necessary, but other experiments are useful and important, like what I wrote in my argument. Your opinions are too extreme."

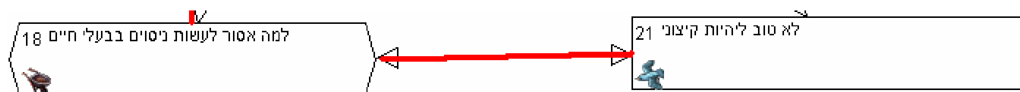

Figure 9: An "argument + evaluation" cluster example from a map titled "biology_experiments5"

6. *Summary, conclusions and/or decisions*

This type of cluster contains contributions in which the discussants are trying to summarize of the discussion, check which of them are for/against a certain solution, reach conclusions, etc. Usually these are the last (or near to last) shapes in any discussion, and are not connected with arrows to other parts of the map.

For example, in Figure 10, shape #15, Lior asks the group a question: "In favor of abortion: Alona, Dan, myself. Only Daniel is against. Is it ok to present the group's opinion as in favor of abortion?" Group members respond, and in shape #27, Lior gives his "final opinion". In Figure 11, the group leader Avi says: "Everybody, we want to summarize the discussion and write only a title/header without a reason, capisce?" and another discussant, Omri, says "OK, so against, and that's final."

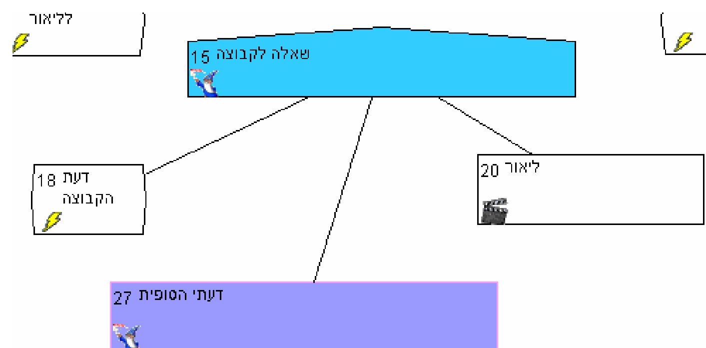

Figure 10: A "summary, conclusions and/or decisions" cluster example from a map titled "genetics_cf11"

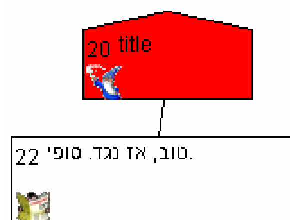

Figure 11: A "summary, conclusions and/or decisions" cluster example from a map titled "physics_avi"

Discussion

In this discussion I would like to focus on several questions that I believe are the most relevant to the methodology used and the initial findings:

1) Is there a dialogic effect on knowledge construction?
2) If there is such an effect, in what manner is it expressed?
3) What characteristics should an analysis method have in order to capture such processes?
4) In the context of question number 3, what are the advantages and limitations of the methodology presented in this paper?
5) What are the prospective challenges this methodology faces?

With regard to the first two questions, the larger part of the discussion will be dedicated to processes related to opposition and counter-arguments in the discussion, given their significance and salience in the data presented above (primarily in the "shared reasoning with argument and counter-argument" and "chain of opposition" clusters) and the emphasis placed on them by theoreticians and researchers (e.g., Leitão, 2000, Pontecorvo, 1993). Some attention will be given to other interactional phenomena and their possible effect on knowledge construction. Finally, I will discuss issues pertinent to methodologies that aim to analyze interaction and their ramifications as to the methodology presented here.

Opposition and counter-argumentation in dialog

The relative salience of clusters/sequences related to opposition and counter-argumentation is perhaps unsurprising, given the central role attributed to such phenomena in the context of argumentative discussions (e.g., Leitão, 2000). Two of the most interesting and potentially significant cluster types found in the current analysis contained elements of opposition (i.e., "chain of opposition" and "shared reasoning with argument and counter-argument"). Another cluster – that of "clarification following feedback" – may also be relevant in this context (see further below); Indeed, in a few cases the same sequence of shapes could be classified as both "chain of opposition" and "clarification following feedback" according to our scheme here.

The presence of sequences or argumentation cycles containing counter-argumentation in discussion is a matter of extensive empirical record in various settings. In the context of Digalo maps, for example, Muller Mirza and colleagues (2007) applied Leitão's (2000) sequence model – in which arguments are followed by counter-arguments, which are in turn followed by replies[15] – to Digalo discussions in which students role-played the participants in a historical debate. In both Digalo maps examined, each argument was the object of at least one counter-argument. The replies (i.e., the third element in the A-CA-R sequence) were generally not simple dismissals and often took into account the counter-arguments that others have suggested, sometimes containing elements countering them. Furthermore, in the context of face-to-face discussions, Pontecorvo (1987) and Orsolini and Pontecorvo (1992) found that

[15] A more detailed account of this A-CA-R sequences model can be found further below

elaborate oppositions are often followed by elaborate counter-oppositions (and also by further counter-oppositions), which is reminiscent of the "chain of opposition" cluster type found in the current research.

One possible effect of opposition and counter-argumentation in peer discussion is that it may lead to better arguments, in the sense that these arguments would be more founded, elaborated and justified. In Table 2 (contributions #8, 15 and 25), presented above, we can see an example of how cycles of opposition and counter-argumentation lead discussants to further elaborate and justify their original statements. The discussant Einat argues against experiments on animals, stating two reasons: availability of other methods of study and problems in generalizing from animal experiments to humans. Dor brings the truth of her first reason into question (cf. Leitão, 2000, for types of counter-arguments), stating that there aren't always other alternatives. In response to this, Einat brings up the moral aspect of animal experiments, which should apply even in cases where there aren't other alternatives. Muller Mirza and colleagues (2007), in the context of Digalo discussions revolving around a historical debate, observed a similar effect, in which "real effort" was made by the participants to articulate their ideas to each other.

This type of effect is not limited to Digalo discussions, or the specific context of small group discussion by high-school and middle-school students on the specific topics mentioned above. To quote one example, in the context of pre-school children discussing two different tasks (scientific and narrative) in small or large groups (face to face), Orsolini and Pontecorvo (1992) found that *disputes* (essentially, counter-arguments) have the effect of eliciting explanations. Similarly, sequences of claims, oppositions and counter-opposition turns between discussants were found to produce a need for justification and consequently explanation in children, as described by Pontecorvo (1987). Pontecorvo (1993), in her review of research concerning social interaction in knowledge construction, further elaborated on this effect, claiming (pp. 301-302) that "oppositional interaction supports children's efforts to produce 'good' arguments, to make explicit certain passages, and to go deeper into the meaning of the discourse."

How, then, can such interactions help discussants "to go deeper into the meaning of the discourse", as described by Pontecorvo (1993)? Baker, Quignard, Lund and Séjourné (2003), analyzed students' interactions in the context of argumentative discussions aimed at improving argumentative knowledge and practices, through the mediation of two different computerized tools (a chat tool and a graphic representation tool). Focusing on the functional category of '*explore and deepen*'[16], taken from the 'RAINBOW' scheme (see there), they elaborated three ways in which students can further their understanding of the space of debate through argumentative interactions (pp. 16-17):

> 1) by expressing a (counter-)argument that builds on already expressed (conter)argument, i.e. 'going deeper' in the argument tree;
> 2) by discussing meaning of argumentative relations, such as questioning or supporting that link (c.f. "backing" or "warrants" in Toulminian models);
> 3) by discussing the meaning of a notion underlying an argument, or by performing discursive operations on an argument.

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[16] Cf. De Laat, Chamrada and Wegerif (2008) regarding *widening* and *deepening* moves.

Nathan, Eilam and Kim (2007) analyzed students' discussions revolving around mathematical problem solving. They stressed the common nature of agreement and disagreement processes as mediating collective activity and their interplay in the discussants' movement towards establishing common understanding, i.e. intersubjectivity (the term is used in a wider sense than the one traditionally accepted, see further below). Their findings were that these processes ultimately lead participants to "express their divergent views in more refined and accessible ways." (p. 524.)

Baker (2003) emphasizes "the way in which the dialectical game of argumentation relates to expressed changes of attitudes towards solutions, and how the playing out of this game goes hand in hand with renegotiation of the conceptual background within which it is situated." (p. 48). Disagreement regarding the epistemic statuses of proposed solutions to a problem can thus lead to negotiations of meaning (e.g., redefining meaning of concepts in context, compromising by creating new solutions). Along similar lines to Pontecorvo (1993) and Nathan, Eilam and Kim (2007), Baker (2003) asserts that "verbalization of problem-solving processes in the context of a communicative interaction can enable interlocutors to elaborate more coherent points of view (Crook, 1994) or at least to become acquainted with the diversity of points of view." (p. 52.)

Up to this point, this discussion purposefully did not touch on several crucial questions pertinent to understanding the possible effects of opposition in discussion: Can we expect opposition expressed in counter-arguments to lead to opinion changes? If so, under what conditions can these changes occur, and what is their nature? And, on a meta-level of conceptualization, **should** we expect opinion changes as a result of peer discussion? That is to say, beyond the question of whether it is possible for counter-arguments to have such an effect, is this necessarily a result we, as educators and/or researchers would like to see? Do we consider changes of opinion to be an expected "good" result for an argumentative discussion? And, an even wider question: should the ultimate goal of a discussion be to reach agreement, or some kind of consensus?

I don't presume to offer full and satisfying answers to the questions raised above. Such answers are beyond the scope of this paper, and indeed, particularly with regard to the meta-level questions, they strongly depend on the theoretical and ideological perspective of the researcher or educator. In the following paragraphs, I will attempt to describe some models and findings relevant to understanding possible changes of opinion as a result of opposition/counter-argumentation, and to give my own personal stance on the other questions mentioned, in light of several theoretical perspectives.

The first question, of whether opinion changes occur, is strongly tied with the second question, particularly regarding the nature of such changes. What, then, happens when a discussant encounters an opposing argument?

Some psychologists would claim that a change of opinion is not very likely to take place when humans encounter information that contradicts their initial thoughts/opinions, given that we unwittingly search for evidence and interpret evidence in ways that are biased towards "existing beliefs, expectations, or a

hypothesis at hand" (Nickerson, 1998). This *confirmation bias* has been demonstrated in various guises and contexts. Specifically in the context of discussions, Nickerson (1998, p. 205) claims that:

> In the heat of an argument people are seldom motivated to consider objectively whatever evidence can be brought to bear on the issue under contention. One's aim is to win and the way to do that is to make the strongest possible case for one's own position while countering, discounting, or simply ignoring any evidence that might be brought against it. And what is true of one disputant is generally true of the other, which is why so few disputes are clearly won or lost. The more likely outcome is the claim of victory by each party and an accusation of recalcitrance on the part of one's opponent.

While confirmation bias has been demonstrated to be a cognitive limitation of human reasoning, the statements above highlight the motivational aspects pertaining to it. The *aims* or *motivations* of the discussants may well be crucial factors when it comes to the question of how contradictory evidence (e.g., counter-arguments) will be handled. Nickerson's description above is that of a heated discussion in which discussants are motivated by the desire to win. In such a context, it is perhaps unreasonable to expect that opinions will change in the direction suggested by the counter-argument. There is also some research that points to further polarization of an original opinion after a counter-argument has been examined, i.e. changes in the **opposite** direction (e.g., Lord, Ross, & Lepper, 1979; Kuhn, 1991).

How do these finding relate to goals and motivations as they exist in classroom discussions? Would we expect similar trends? In my view, the specific context of educational discussions is essentially different to that of a political conflict in the "real world", for example. While the motivation to "win the argument" may certainly exist in one or more of the discussants[17], the pedagogical settings typically include a strong emphasis on finding the right solution to a problem, learning new concepts, and/or reaching certain communal goals. Participants are not necessarily rivals competing for resources – they are often part of the same discussion group, classmates, and, in some cases, friends. Even when they role-play enemies or competitors, and act according to motivations not truly their own, the over-arching educational goals of the discussion may still be there, in the background. Teachers typically establish ground rules for discussion, conventions as to how arguments and counter-arguments should be treated, how the other should be treated in the discussion. Therefore, assuming a different motivational framework for argumentative discussions in a classroom context, it may well be that confirmation bias and polarization effects will not play such a strong role in them.

Let us now examine one of the most influential and well-elaborated models regarding the effect of counter-arguments in the context of collaborative knowledge building,

[17] I should add here as a side-note that I do not see this type of motivation as negative in itself. The real "danger" of such motivation is when it's the sole motivation of a discussant, and/or when ground rules are not properly established and/or when the students are not motivated to maintain such ground rules, i.e. when the motivation is to win "at all costs". When the desire to win is accompanied and tempered by more "pedagogically-acceptable" motivations (e.g., to learn, to understand, to improve) and/or more "socially-acceptable" motivations (e.g., to be an integral part of the group, to help my **group** reach better results), it can – in my view – contribute to argumentative processes by raising the overall motivation to engage in them in significant ways.

that of Leitão (2000). Leitão considers counter-argumentation to be "a basic developmental mechanism", and further argues (p. 33) that "the experience of being opposed releases processes of belief reappraisal that enable people to move on from old (already existing) to new perspectives on a topic". The basic unit used in her model to analyze such processes is a three-part sequence, in which the first element is an *argument* (A), the second is a related *counter-argument* (CA) and the third is a *reply* to this counter-argument (R). (Incidentally, the "chain of opposition" cluster type found in Digalo maps as analyzed above can be seen as a sub-type of these A-CA-R sequences, cf. also the *claim, questioning or opposing,* and *appeal to warrants and backings* sequences described by Pontecorvo, 1987.)

In Leitão's model, counter-arguments can be categorized as *supporting the other side of the question*, *bringing the truth of a claim into question*, or *questioning a reason-position link*. Similarly, the response, or reply to counter-arguments can assume four different forms (see also Figure 12):

1) *dismissal*, in which the information conveyed in the counter-argument is dismissed, and the original argument remains more or less as it was;
2) *local agreement*, in which there is some (minor agreement) with the counter-argument (or elements thereof), though the previous position is still defended and the original argument stands (more or less);
3) *integrative reply*, in which the content of the counter-argument is integrated into the original argument by allowing some exceptions or conditions to the original position, and/or by changing the degree of certainty associated with the original argument (e.g., confessing less certainty, cf. Baker, 2003, discussed further below), and/or rephrasing the original argument or the counter-argument (lexical changes, may be related to negotiation of meaning, see Pontecorvo, 1993 and Baker, 2003, above); or
4) *withdrawal of the initial view*, altogether.

According to this model, therefore, a counter-argument does not have to be fully accepted or fully rejected – there remains the possibility of modifying, restricting, and/or specifying positions so that more integrative arguments are created ("new forms of knowledge"). More drastic changes in position, such as withdrawing an argument completely, are less likely to occur in a discussion. However, "more subtle forms of revision of the speaker's position do commonly occur during argumentation, as seen in integrative replies." (Leitão, 2000, p. 357.) It may further be said that instances of both local agreements and integrative replies can be seen as results of negotiation of meaning and/or refinement of opinions (as discussed above).

Since Leitão's model has been applied to Digalo discussions in the work of Muller Mirza and her colleagues (2007), we are in a position to examine these predictions in a context most relevant to that of the maps analyzed in the current research. Muller Mirza and colleagues (2007) found that, most often, the A-CA-R sequences they located in two discussion maps (role play around a historical debate, the Valladolid Controversy) ended with replies that fit into the "dismissal" category. This finding matches the prediction arising from research on confirmation bias (Nickerson, 1998). However, we should remember that the participants played rival factions (representing the conflict between Spanish governmental and religious organizations and those of the Aztec Indians), and so their motivations may have been strongly

influenced. It should also be noted that in the data of Muller Mirza and her colleagues', A-CA-R sequences sometimes did end with an integrative reply, in which discussants took into account counter-arguments suggested by others and added "nuances" to their initial claims. They did not find instances of local agreement or, unsurprisingly, complete withdrawal.

Although the analysis presented in the current research did not use the same method or terminology, I believe that we are likely to find similar results when looking at the relevant "chain of opposition" and "clarification following feedback" clusters/sequences found here. My impression is, though, that instances of local agreement and/or integrative replies would be more common in the current data, while dismissals would be less common (than in the case of Muller Mirza et al.'s data). It is not my purpose here to re-analyze the data corpus of the present research according to the A-CA-R model, but I would like to further demonstrate different routes of opinion reappraisal as they are also found in the current data: dismissal, local agreement and an integrative reply (no full withdrawals were found).

The "chain of opposition" example shown in Figure 8 above can be considered a "dismissal" according to Leitão's terminology. Anat's objection to cloning is not affected by Achiav's claim in favor of cloning (that it can save human life). Although she concedes that "that's a good point," she does not assimilate it or truly address it in any way, appealing instead to authority by saying that "the fact is that the government prohibits any kind of cloning."

Two other examples of A-CA-R sequences can be found in Table 2 above, regarding the exchanges between Einat and Dor and Roni and Linor. The exchange between Einat and Dor (contributions #8, 15 and 25 in Table 2), previously mentioned as an example of further elaboration and justification following a counter-argument, can also be seen as an instance of "local agreement" – Einat implicitly concedes that there are sometimes no other options to get results (other than experimenting on animals), which brings her to add a new backing to her original argument (the moral aspect).

In another example, a sub-set from the same "shared reasoning with argument and counter-argument" cluster that was also classified as "clarification following feedback" (see contributions #32, 44 and 51 in Table 2, presented also in Figure 4), Linor challenges Roni's assertion that "…if it helps humans then I have no choice and I have to agree to experiments", by asking her why animals should suffer to help humans, and mentioning that she feels pity for them. Roni's reply can be classified as an integrative reply, as it allows for "some exceptions or conditions to the original position", with Roni's added statement that she is "against unnecessary experiments and the conditions in which animals are kept."

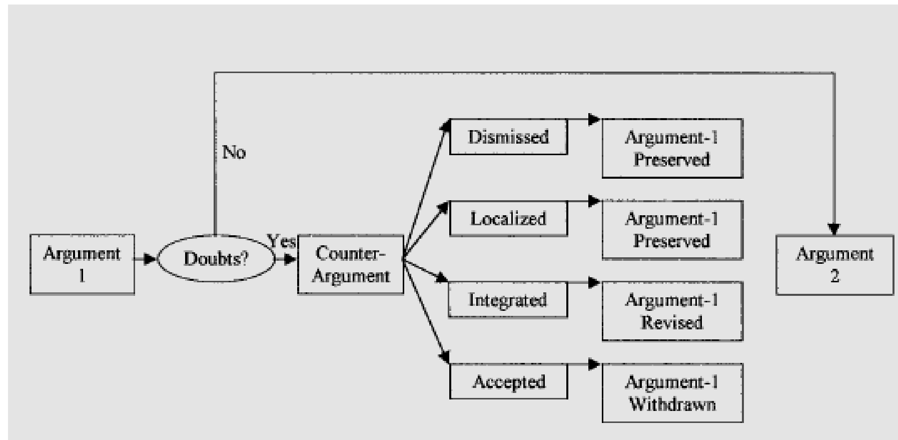

Figure 12: The process of argument re-appraisal (reproduced from Leitão, 2000, p. 357)

An interesting finding, vis-à-vis the above examples, is that of Baker (2003). Baker analyzed the work of dyads solving a problem of interpreting sound phenomenon in physics, through the medium of a CSCL discussion/collaboration environment called CONNECT. In this environment, discussants are expected to state their attitudes regarding statements/suggested solutions (i.e., indicating 'YES' if they agree, 'NO' if they do not, and '?' if they are not sure). In this way, possible changes in these attitudes as a result of discussion can be tracked. Baker discerned three options with regard to attitude change, comparing answers before and after a discussion episode:

1) No expressed change (YES→YES, NO→NO);
2) Strengthening in epistemic value, i.e. the solutions/statements become more viable/acceptable, discussants are more sure of them, etc. (NO→?, NO→YES, ? →YES);
3) Weakening in epistemic value, i.e. the solutions/statements become less viable/acceptable, discussants are less sure of them, etc. (YES→?, YES→NO, ? →NO).

Baker (2003) found that argumentation more often leads to weakening of attitudes than to no change or to strengthening of attitudes towards a specific solution to the problem (cf. the second type of integrative reply in Leitão's model from 2000, which concerns changing the degree of certainty associated with the original argument, following opposition). Baker also found that collaboration between students with different interpretations of sound can lead to the elimination of less elaborate or adequate solutions to the problem.

The above findings are not wholly explained by the cognitive-epistemological dimension. That is to say, the merit of possible counter-arguments in itself was not the only factor contributing to attitude changes. Baker (2003) noticed that, "in several cases, the students' attitudes seem to weaken because it would only be 'fair' to their partners to weaken their attitudes a little, given that doubts have been raised with respect to a statement." (p. 72.) Here we see a finding that is at odds with confirmation bias predictions (Nickerson, 1998), thus strengthening the argument that establishment of ground rules and suitable motivations for educational discussions can affect processes of opinion change. It should also be said, as noted by Baker himself, that this topic was relatively new to the discussants, who therefore had no fixed positions about it (making the likelihood of change greater).

In summary, it appears that changes of opinion can occur as a result of counter-argumentation in interaction, but that these changes are typically not dramatic (i.e., local agreements and integrative replies are likely more frequent than complete withdrawals) and, at least in educational contexts, are perhaps more likely to be directed towards weakening of attitudes rather than towards strengthening them. Social[18] and motivational factors as well as the content area discussed are relevant and sometimes crucial factors in these processes.

We now return to the meta-level questions raised earlier in the discussion, regarding the nature and goals of the discussion process and the place of counter-argumentation as a dialogic process within it.

Leitão (2000) and Nathan, Eilam and Kim (2007), reject traditional views[19] which see discussion as a process aiming at reaching a shared agreement, or consensus. According to such views, a state of conflict or disagreement is considered to be a "negative" state, stemming from "blindness". People disagree because they do not have enough information; they are "blind" to possible counter-arguments. Such traditional views see discussion as a "movement from a state of disagreement or misunderstanding to one of agreement or symmetry" (Nathan, Eilam & Kim, 2007, p. 525, cf. the example cited above from Nickerson, 1998), "which implies the withdrawal by one of the arguers from his or her original position" (Leitão, 2000, p. 358).

Given that the context of every day discussion is typically not that of "pure", formal logic, Leitão (ibid.) stresses "more subtle forms of conciliation and compromise solutions that end a wide range of conflict talk in every day life." In such cases, the value of a counter-argument is not in invalidating a claim but in calling it into question, causing the discussants to re-examine their views. Nathan, Eilam and Kim (ibid.) go even further to claim that "the dynamics toward and away from convergent ideas appear to be instrumental in fostering sustained and engaging discourse and influencing the representations that students propose during problem solving." This is particularly interesting given the subject matter they chose to illustrate their ideas with – that of a **mathematical** question (how can a pie be divided into 8 equal parts using only 3 incisions), in which a solution to the problem can certainly be rejected as unsuitable.

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[18] The sequences in Leitão's model (2000) do not necessarily reflect turn-taking, and may be used to represent arguments and counter-arguments as expressed in, say, a monologue or argumentative writing from a single individual. One of the criticisms leveled against this model (cf. Pontecorvo and Pirchio, 2000) is that it doesn't allow enough substance to the role of the other, to opposition between individuals rather than ideas. I will return to this point in the methodology-oriented part of the discussion.

[19] Leitão's frame of reference in this context is that of Piagetian views, as well as later models regarding argumentation such as those of Van Eemeren and Grottendorst (1992) and Miller (1987). She uses the terms "argumentation", "argument", "counter-argument" and "conflict resolution" in this context. Nathan and colleagues, on the other hand, focus on the concept of "intersubjectivity", using terms such as "agreement", "disagreement", and "shared understanding", citing psychologists and sociologists such as Cole (1991), Stahl (2006), Lotman (1988) and Schegloff (1992) as examples of more "traditional approaches" and building on the participatory view of intersubjectivity promoted by Matusov (1996). Although their frameworks and terminology are different, their concepts and ideas they elaborate on, as well as their central arguments in this context, are similar.

Building on these ideas, I can now offer some tentative (and subjective) answers to the previously-mentioned meta-questions. The discussion's content area and discussants' motivations should also be considered. Yes, I think we **should** expect opinion changes as a result of peer discussion, but under certain conditions and settings. We should not necessarily expect drastic changes – the **subtler changes** described by Leitão (2000) and found in the current data (and in the data of Muller Mirza, et al., 2007) are more fitting to the context of classroom discussions, particularly those dealing with open-ended questions. Even if required to issue a joint group decision after the discussion, the quality of the discussion in my view would not depend primarily on the result (e.g., solution a or b), but on the processes the participants went through (e.g., re-considering their initial views even if they don't wholly reject them, moving towards shared understanding, refining and further elaborating on their arguments) and their adherence to a previously (and pedagogically) established set of norms and ground rules.

The content area and the specific question to be discussed are of course of immense importance in this case. When dealing with a problem solving situation in one of the "hard" sciences, provided that there is only one possible solution to the problem, I would expect that the students reach that solution, and that this would involve adapting or completely removing initial statements (should they be proven "wrong"). However, even under such conditions, I would still highly stress an evaluation of the process, since the "right" solution can be reached in the "wrong" ways (e.g., appeal to authority, dominant student forcing their opinion). And although discussants may intuitively think of the "correct" solution early on, I would like to see some evidence in the discussion that they considered and rejected at least some of the "wrong" alternatives. As I mentioned earlier, the statements in the last couple of paragraphs are largely statements of personal preference and pedagogical ideology on my part, and should not be seen as integrative conclusions of a comprehensive research review.

Some other interactional phenomena

The previous section in the discussion was dedicated to disagreement between discussants (as expressed through elements of opposition such as counter-arguments). This section, dedicated to several other phenomena (which do not necessarily involve disagreement), may seem short and succinct in comparison. However, given the great importance of disagreement in educational discussions (both theoretically and empirically), and the limited scope of this paper, I do not believe that this seemingly disproportional representation is unjustified. In this section, I wish to focus on phenomena relevant to the following cluster types: "shared reasoning with argument and counter-argument" and "clarification following feedback" (mentioned briefly above) and "different backings for the same claim". I do not discuss further the "argument + elaboration" or "summary, conclusions and/or decisions" cluster types, given the problematic nature of the former (in terms of both reliability of coding and relevance as an interaction unit[20], see further explanation in the next section of the discussion) and the relative rarity of meaningful clusters[21] of the latter type.

[20] As discussed in the section dedicated to methodology and the unit of analysis, I have come to the realization that in order to best represent interaction, sequences (or clusters) of at least 3 discussion moves are required. The "argument + evaluation" clusters are typically paired shapes, and while they may be significant in how they demonstrate the critical thinking of one of the discussants, and are

Pontecorvo (1993) described several phenomena relevant to peer interaction in the context of classroom discussions. One of these phenomena, the positive effects of disagreement and opposition between children on levels of explanation and understanding, was discussed in the previous section. The other three phenomena, while potentially relevant to instances of disagreement, are conceptually independent of it. They are as follows (ibid., p. 297):

1) Emotional sharing out of reasoning and thinking: Each person only has to think of and say one "piece" of the discourse, which can be used as a block for building knowledge by another and which can also go back to the first speaker in a more developed form.
2) Openness to other children's contribution: This phenomenon is evident in the co-constructive sequences when children seem to think together at the level of sentential cooperation. (Sentences or even clauses are completed with the contribution of more than one speaker.)
3) Children's assumption of different and complementary discursive roles within the group. These include the skeptic, the encyclopedic, and the deductive reasoner (see Zucchermaglio, 1991).

A similar phenomenon to the second phenomenon listed above was found by Resnick, Salmon, Zeitz, Wathen and Holowchak (1993), who used the term '*sentential cooperation*' to describe situations in which one speaker completed the idea of another. Orsolini and Pontecorvo (1992) spoke of a similar phenomenon, which they termed '*mutual continuations'* (i.e. children extending previous contributions by elaborating on previous statements).

Nathan, Eilam and Kim (2007) further report that in the context of the task given to the students in the lesson they analyzed (joint problem solving in Mathematics), the participants "worked together, continually reflecting on one another's ideas… were engaged in a *recursive communication process*: They listened to one another and were genuinely interested in others' ideas and contributions… built on others' ideas, even when they did not agree…[22]" (p. 554.)

Suthers (2006, p. 1) sees such patterns, in which participants take up and build on prior contributions, as activities which "constitute an intersubjective cognitive activity distributed across persons." He coined the term "uptake" to denote them and elaborated on a methodology for revealing them (Suthers, 2006; Suthers & Medina, 2008, see also in the next section).

Dreyfus, Hershkowitz and Schwarz (2001), with different goals and a different framework/methodology for analysis, were also interested in the manner in which epistemic actions are distributed, and in which actions are coordinated between peers.

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interesting as elements in larger clusters, without the response of the first discussant they hold less descriptive value for the interaction itself.

[21] In the current data sample, these clusters are fairly rare and are typically the last (or near to last) shapes in any discussion, so that they do not lead to further, measurable results within the discussion. In most cases found, the argumentative content of such clusters was fairly superficial and they were more oriented towards task-management.

[22] Cf. co-elaboration of understandings also in Baker (2003) and Baker, Quignard, Lund and Séjourné (2003), mentioned further above.

They additionally posed the question of whether it is possible to consider a group of discussant peers solving a problem together as a cognitive entity that abstracts structures, coming to the conclusion that it possible[23].

Returning to the current research, let us revisit the characteristics listed for the "shared reasoning including argument and counter-argument" cluster type:

> Clusters of this type involve three or more users and must contain both an argument and a counter-argument. Furthermore, there should be some indication that this reasoning is shared, that the discussants are listening to each other and building on each other's arguments, not just stating their own opinions or dismissing those of others with counter-arguments.

Looking at the cluster example shown in Figure 2 above (see also Table 2), we saw that although there is quite a lot of disagreement, opposing opinions aren't ignored or dismissed, and opponents aren't attacked. Rather, the students appear to try sharing points of view and points of agreement even as they are disagreeing (see for example shapes 32, 44, and 41 in Table 2). This example goes beyond merely responding to counter-arguments and adjusting one's own arguments. Here we see *emotional sharing out of reasoning and thinking* as well as *openness to the contributions of others*. True, these phenomena are not expressed quite in the same ways as in the research surveyed by Pontecorvo[24] (1993), but I believe they share similar motivations and effects.

The example above also evokes the findings of Resnick and colleagues (1993), who described a related phenomenon[25], that of '*thematic continuation'* – the ways in which the thematic content was distributed between partners during the discussion. They found that themes were not explored in "successive, well-delineated blocks", but rather that they were "distributed across speakers and over time". The graphic representation of the discussion example seen in Figure 2 can serve as an illustration of this finding.

The third phenomenon mentioned by Pontecorvo (1993, see above), that of "children's assumption of different and complementary discursive roles within the group", was not revealed in the analysis of the corpus of discussions presented in this research[26]. However, it is certainly relevant to Digalo discussions in general. The contextual settings and pedagogical instructions of the teacher may foster this process; cf. the example of role play from Muller Mirza and colleagues' 2007 research. The particular Digalo discussion maps analyzed herein were also previously analyzed according to another method, which classified individual shapes according to several categories (Hever et al., 2007, McLaren et al., 2007). One of the categories used to

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[23] Given that they all share in the same *activity*, the same overall goals.
[24] It should be noted that the context of discussions reviewed by Pontecorvo (1993) was that of face-to-face oral discussions, in which interaction is by nature sequential and linear (and students can engage in finishing others' sentences). In the context of Digalo, both the medium and the representation of the discussion are written and non-linear, so that theoretically similar phenomena are manifested in somewhat different ways.
[25] Similar to the first one mentioned by Pontecorvo (1993), but without stressing the emotional aspect and explicitly referring to use of previous contributions as building blocks.
[26] Cf. the "methodological considerations" section of the discussion, below.

classify shapes was that of "task management[27]". While Pontecorvo (1993) mentions more content-related and argumentation-oriented discursive roles (e.g., "the skeptic", "the encyclopedic"), the assumption of managerial and coordinating roles is also relevant in this context, and strongly tied with the norms of Digalo discussion in a particular classroom[28]. I can additionally offer anecdotal evidence pointing to the assumption of a role more similar to those mentioned by Pontecorvo. Overheard in one of the classrooms in which Digalo discussions were held, one student announced that he is taking it upon himself to play the 'devil's advocate' in a discussion, wishing to spark it up, since "it was boring and everyone was agreeing."

Dreyfus, Hershkowitz and Schwarz (2001) elaborated a complex model called *the dynamically nested RBC model of abstraction*. In this model, RBC stands for epistemic actions of *building with*, *recognizing,* and *constructing[29],* which are dynamically nested within each other so that, for example, recognizing actions can nested in both building-with and constructing actions, localized construction actions can be nested within larger construction actions, etc. Dreyfus and colleagues claim that these actions can be **distributed** between peers interacting to solve a mathematical problem, so that one person's recognition of a structure can contribute to it being applied and adapted by another. In my view, this type of process can also be seen as "assumption of different and complementary discursive roles", though to a less extreme and explicit degree (Pontecorvo, 1993). While the specifics of the above-mentioned RBC model (Dreyfus, Hershkowitz & Schwarz, 2001) are perhaps more suitable for analyzing discussions such as those mentioned in Baker (2003) and Nathan, Eilam and Kim (2007) – the context of collaborative problem solving in mathematics/science – the additive effect of contributions from different members of the group, already touched on above, is crucial in our context as well. 'Roles', or rather, 'actions' and 'responsibilities' can be distributed implicitly (or explicitly) amongst discussants. Beyond the notion of 'uptake' (Suthers, 2006) and other relevant concepts discussed earlier, since we can consider a discussion (or, indeed, a discussion map) to be the product of a **group**[30], we can analyze and evaluate it as such. In this case, a relevant addition, even if it is not explicitly re-used (i.e. even if there is no explicit uptake or application and adaptation by others), can add to the quality of the over-all structure. This is the very value I ascribe to the "different backings for the same claim" clusters (example in Figure 6). I acknowledge that the addition of more backings for a claim can be more meaningful if it's done in an integrative way, picked up by others, etc. I also recognize the importance of having different sides of the argument represented, and would not consider a discussion or an argument based only on different backings for the same claim to be optimal. However, having more numerous and elaborated justifications for either side of an

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[27] Cf. also the "control" and "attention" categories in Dreyfus, Hershkowitz and Schwarz (2001).
[28] It is not uncommon for teachers at the Ziv School in Jerusalem, Israel, for example, to appoint a member of each group to be a "group leader", assuming some moderation duties (e.g., ensuring participation, proper use of links, re-arrangement of the map, summarizing, etc.). In some cases, students that are not the official "group leaders" assume such responsibilities on their own initiative.
[29] *Recognizing* – recognizing a familiar mathematical structure as inherent to a given mathematical situation. *Building-with* – combining existing artefacts in order to satisfy a goal such a solving a problem or justifying a statement. Here, the goal is attained by using knowledge that was previously acquired or constructed. *Constructing* – assembling knowledge artifacts to produce a new structure to which the participants become acquainted. Here, the process of constructing/reconstructing of knowledge is often the goal of the activity.
[30] Cf. Dreyfus, Hershkowitz and Schwarz (2001).

argument cannot be discounted, since it improves the quality of the overall discussion as a **group product**. Furthermore, having different discussants "covering" different aspects (e.g., different types of backings) within the discussion may also, under some conditions, be considered a sharing of roles or responsibilities[31].

Having explored ideas related to the "shared reasoning with argument and counter-argument" and "different backings for the same claim" cluster types, the final part of this section in the discussion will be dedicated to the "clarification following feedback" cluster type. In the findings section above, it was described as a cluster that is typically a sequence of three shapes, in which two people interact. The person who made the first contribution in the sequence further elaborates it in a second contribution, in response to relevant feedback from another. In the two examples presented in Figure 4 and in Figure 5, the feedback took the form of a question, but that is not always the case. The purpose behind the feedback may also vary: in Figure 4 (the Roni and Linor example also touched on in the previous section of the discussion), the feedback can be considered as an opposition aimed at getting someone to reappraise their original argument. In this example (and in several other instances found in our data), the "clarification following feedback" cluster can also be labeled as a "chain of opposition" cluster. In other cases, however, the purpose of the feedback can be simply to get a clearer explanation or more information regarding a statement.

Pontecorvo (1987) focuses on a three-part sequence in which a *claim* is followed by *questioning or opposing* ("often done by someone who assumes the role of skeptic"), which is in turn answered by an *appeal to warrants and backings*. Questioning in this context appears to be a form of opposition or a challenge, i.e. questioning the credibility or validity of the first statement. In this sense, it is similar to the "clarification following feedback" clusters that are also "chain of opposition" clusters.

Orsolini and Pontecorvo (1992) described a phenomenon equivalent to that revealed in the "clarification following feedback" in which the feedback was aimed at obtaining clarification and explanation – "*cycles of contingent queries-answers"*. Since their study was done in the context of a classroom discussion, these cycles were typically initiated when a teacher requested clarification and explanation following a previous turn from a child. Although this is not a similar context to that of Digalo discussions in our case, which stress dialog and interaction between peers, the effect of the queries is similar – the earlier contribution is further elaborated on.

De Laat, Chamrada and Wegerif (2008) described *widening* discussion moves as attempts to "break away" from a particular perspective by "either questioning it or presenting a new perspective," thus opening up the discussion space "into new and unknown territories."

[31] This can also be an aspect of the pedagogical instructions, e.g. a teacher saying to the children before the Digalo discussion that each group member is responsible to elaborate on a certain aspect of the problem (which can pertain to both pro and con arguments), or a teacher dividing different texts among members of the discussion group so that each of them draws backing from a different database of evidence.

Gunawardena, Lowe, and Anderson (1998), in an analysis framework tested in the context of peer discussions via computer conferencing, include operations[32] of asking and answering questions in the two first stages of discussion. In both cases, the questions are aimed at exploring the space of debate (cf. De Laat, Chamrada, & Wegerif, 2008). In the first phase, that of *sharing/comparing information*, the discussants explore their initial positions and ideas, and, in this context, ask and answer questions to clarify details of statements. In the second stage of discussion according to their model, that of *discovery and exploration of dissonance or inconsistency among ideas, concepts or statements*, questions are asked and answered in order to clarify the source and extent of disagreement. In both instances, it seems as though the questions are oriented towards clarification purposes (although they could potentially have other motivations that the analysis scheme does not touch on).

The interaction analysis model applied by Dreyfus, Hershkowitz and Schwarz (2001) to dyadic problem solving in Mathematics does not appear to have made the distinction between questions with different purposes in its categorization scheme. In fact, the categorization scheme explicitly referred to them in the terms: the label of '*query*' was assigned to utterances which question previous utterances, either for clarification or opposition purposes.

Baker's analysis (2003), on the other hand, made a clear distinction between the *speech act category* (e.g., interrogations, assertions, exclamations) and the *pragmatic function* of each speech act (e.g., attacks, defenses). Further refinement of the clustering scheme presented in this paper could, in my opinion, benefit from a similar distinction (see also the methodological discussion in the next section).

The effects of challenges and opposition[33] in the context of discourse between peers were already elaborated on in a previous section of the discussion, but what of the effect of questions or feedback aimed primarily at obtaining clarification, understanding better the other's position, receiving further information, etc.?

An obvious answer would be that they lead to arguments that are clearer and more elaborated (e.g., Orsolini and Pontecorvo, 1992). They serve also to help explore the space of discussion (e.g., Gunawardena, Lowe, and Anderson, 1998) and may contribute to processes of negotiating meanings between the discussants. Dreyfus, Hershkowitz and Schwarz (2001) pointed out that queries from another may give one the opportunity to reflect on their own ideas[34], and, if one of the discussants is more competent than the others, may lead to explanations that would expand the discussants' *zone of proximal development* (in the Vygotskian sense) and thus facilitate abstraction processes.

The discussion so far focused on dialogic effects related to collaborative discussion and knowledge construction. It explored several phenomena in this context, and several models for their analysis. The final parts of the discussion will be devoted to

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[32] They refer to them as "operations", but it should be noted that this term does not necessarily reflect their status from an Activity Theory perspective.
[33] In this I include both contributions that were **motivated** by the wish to challenge/oppose, and contributions that were **interpreted** as such (regardless of their original intention).
[34] It should be noted again that they don't make a distinction between challenges and clarification questions.

the subject of methodology, attempting to asses the suitability of the methodology used in the current paper to its purposes and describe the prospective challenges it faces.

Methodological considerations

The methodological approach presented in this paper is at an early stage of conception. The list of cluster types and the specific characterization of each of these types is still a work-in-progress. This work is exploratory and initial, and should be viewed in this light. However, the findings from this research and an attempt to relate them to other findings and analysis methods[35] offer us the opportunity of evaluating its potential usability and pin-pointing elements which require further work and improvement. The examination of this methodology will be done in relation to its theoretical context, goals and implementation settings.

Theoretical perspectives and research on computerized discussions (and indeed, discourse in general) vary greatly in their tenets and focus (for a more comprehensive review, see Lotan-Kochan, 2005). Unsurprisingly — since this work is in a similar vein — most of the researchers and theoreticians cited in this paper (e.g., Pontecorvo, 1993; Leitão, 2000; Dreyfus, Hershkowitz, & Schwarz, 2001; Nathan, Eilam, & Kim, 2007; Baker, 2003) share an over-arching characteristic, namely a focus on cognitive processes (e.g., reasoning, argumentation, abstraction, problem solving) from a social, interactional, dialogic and/or collaborative point of view, and attempt to identify and describe related phenomena.

Even when researchers share this characteristic, they may exhibit considerable variance with regard to the specific assumptions, goals, contexts and, consequently, scope, units of analysis and specific methodological practices. Leitão (2000) and Pontecorvo (1993), for example, interpret the dialogic dimension in a different way. Leitão (2000) criticizes turn-taking approaches to discourse such as that of Pontecorvo (1993), because in her view they do not suitably represent the dialectical nature of argumentation, which implies opposition between views (and not necessarily between individuals). Pontecorvo and Pirchio (2000) countered this argument from a developmental perspective, claiming that, while adults may be able to incorporate the other's view in their talk, young children "require the social support (in a Vygotskian meaning) of the other." These differences have ramification with regard to the unit of analysis. While Pontecorvo (and her colleagues Orsolini and Pirchio – see several papers cited above) would segment the discussion relying on turn taking (i.e. each time the speaker changes, a new turn begins), Leitão would further segment each turn according to its content.

Another example of such significant differences in the unit of analysis as a result of differing tenets can be seen in the contrast between the models of interaction elaborated by Gunawardena, Lowe, and Anderson (1998) and Nathan, Eilam and Kim (2007). Gunawardena and her colleagues base their analysis on the assumption that a discussion can be divided into stages, or phases, and furthermore, that these stages proceed according to a fixed order and culminate in a final stage that represents the optimal result: statement of agreements and/or application of newly constructed

[35] See the previous sections of the discussion.

knowledge (less successful discussions fail to reach the final stages). This assumption is anathema to Nathan and his colleagues, who see agreement and disagreement as processes of a common nature, whose interplay fuels and promotes the process of discussion and the discussants' movement towards establishing common understanding – and not necessarily common agreement. In such a view, the analytic focus would be on chains or sequences of interaction that show this interplay. The stages model, on the other hand, codes each speech with the purpose of characterizing the specific stage the discussants are engaged in.

The methodology presented in this paper shares the over-arching interest in social/interactional processes related to knowledge construction, with the specific goal of identifying collaborative argumentation as it is expressed in Digalo discussion maps. Following Leitão (2000), I believe that the level in which these processes can and should be analyzed or traced is primarily (or, at least, initially) the micro-genetic level, or, as Pontecorvo (1993) calls it, the "molar level", in which conversational moves are analyzed.

I put it forward also that, in order to identify truly significant interaction-related phenomena, the labeling or categorization of units should be done at the level of compound units, comprised of at least 3 sub-units representing contributions from several people (cf. Leitão, 2000; Muller Mirza, et al., 2007; Nathan, Eilam, & Kim, 2007, etc.), since smaller units cannot satisfactorily represent the immediate, localized context of interaction and the interplay between discussants. Having been exposed to a wider body of research in various contexts and reflecting on the methods and findings of others (elaborated in earlier parts of the discussion), I no longer believe that the smallest relevant interaction unit is that of a contribution and a related response (cf. the paired-shapes level of analysis undertaken by the Argunaut research team and described in Hever at al., 2007 and McLaren et al., 2007). True, it does show elements of interaction, but this interaction is in my eyes **one-sided** and therefore not a suitable for unraveling the truly interesting mechanisms of co-construction and co-elaboration of knowledge.

Like Pontecorvo and Pirchio (2000), I am also more interested in the dialogic interplay between **people** and not between abstracted views or "sides" of a dilemma. People are complex, and their opinions can be complex and involve both arguments and counter-arguments, while still comprising a coherent whole. The sub-units comprising the clusters in the current analysis take into account the entire contents of a Digalo "contribution" or "shape", representing a "turn"[36], a complete unit of meaning as delineated by the discussant himself or herself. I therefore find them more suitable for my purposes than their breakdown into smaller utterances according to which side of a dilemma they support, or whichever alternative idea-level unit (e.g., Henri, 1992; Resnick et al., 1993).

Furthermore, I believe that the mechanisms I am interested in are often more complex than can be faithfully represented by a fixed sequential view. Take, for example, the

[36] "Turn" in this context is somewhat different than in the context of face-to-face conversation. Digalo maps, while incorporating a temporal dimension, are not strictly sequential as far as discourse goes. Discussants can write and submit contributions at the same time, and similarly, since the written content of contributions is always available and scattered around the map, they do not always read them in the order in which they were written.

A-CA-R sequences described by Leitão (2000) and applied to the Digalo data of Muller Mirza and colleagues (2007). The first example of argumentative sequences they present (see Table 2, ibid.), is that of a response, followed by two independent counter-arguments from different people (which could have been created simultaneously and irrespective of each other), and then by a reply that integrates responses to both. The structure of interaction cannot, in my opinion, be accurately represented by using a simple triple chain, particularly considering the specific affordances and characteristics of the Digalo tool[37]. And what of longer chains, such as those found by Pontecorvo (1987) and Orsolini and Pontecorvo (1992)? Should they be represented by more than one A-CA-R sequence? One advantage of using a holistic clustering method such as the one described here is that it is very flexible in this respect[38]. On the other hand, it is also a disadvantage: the definitions lack further refinements, the relationships between the sub-units of a cluster are not always elaborated to a sufficient degree, and a cluster type definition that is too wide and irregular loses some of its descriptive value[39].

With regard to the aspects presented above, it seems to me that the current methodology is adequate to at least some degree, as it allows for the detection and description of **some** relevant phenomena in a flexible way that is suited to the particular tenets I hold regarding discourse and to the affordances of the Digalo discussion tool. However, as hinted at several times during the course of this discussion, it is not without its faults.

First of all, and perhaps worst of all, any methodology relying on searching for clusters in a Digalo map representation is inherently faulty as far as discovering certain types of important patterns, e.g., change of opinion. Although the Digalo map represents, in a way, both a process and a product, not all relevant discursive actions are represented in it in a visible way. Students can change their opinion not only by adding a new shape with new content to the map, but also by **editing the content of** and/or **deleting** previous shapes. Since the Digalo map only shows the **current** content of each shape, simply following the flow of discussion by reading the contents of inter-linked shapes is not enough to discover all types of relevant changes. While Digalo log files are available that detail each action and its properties, it is near impossible to detect patterns by simply reading the action logs, since the relevant **contingencies** (Suthers & Medina, 2008) are not made salient in this type of representation. One of the awareness features integrated into the Argunaut system's Moderator's Interface (briefly described in the introduction of this paper, more fully elaborated in Hoppe, et al., 2008) may address this problem. This feature, called the Chat Table, is a representation of the discussion in a sequential way, according to the actions log but arranged in a way that brings edit and delete actions and at least some of the relevant contingencies to the fore. The example in Figure 13 shows a change of

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[37] As indicated by Muller Mirza and colleagues (2007) themselves, "the argumentative sequences do not follow a chronological order, meaning that participants have taken the benefit of the written and stable form of the discussion and have constructed their arguments and counterarguments on the basis of the whole picture the Digalo argument maps provided." (p.262.)

[38] The dynamically nested RBC model of abstraction (Dreyfus, Hershkowitz, & Schwarz, 2001) is another example a flexible model, though it appears to be even more complex and oriented more towards a specific context of discussion (problem solving in Mathematics/Science).

[39] And certainly its usefulness for the elaboration of Query-By-Example algorithms, as will be discussed further below.

opinion pattern as it was revealed by browsing the discussion using the Moderator's Interface Chat Table. Each of the discussants (in this case, represented by the pseudonyms avia.e., vladirtm, omrytheking7, DEAN and tamar) is allotted a column in which each action they perform on contents of their discussion shapes is displayed along a time sequence (from top to bottom), as a "bubble" with text in it. Deletions of content (and of entire discussion shapes) are denoted by the use of strike-through font (~~thus~~), added text is denoted in black font and "old" text in faded gray. Bolded text represents text placed in the "title" slot of the shape. Clicking on one of the "bubbles" will highlight in bright orange all the "bubbles" that represent actions on the same shape.

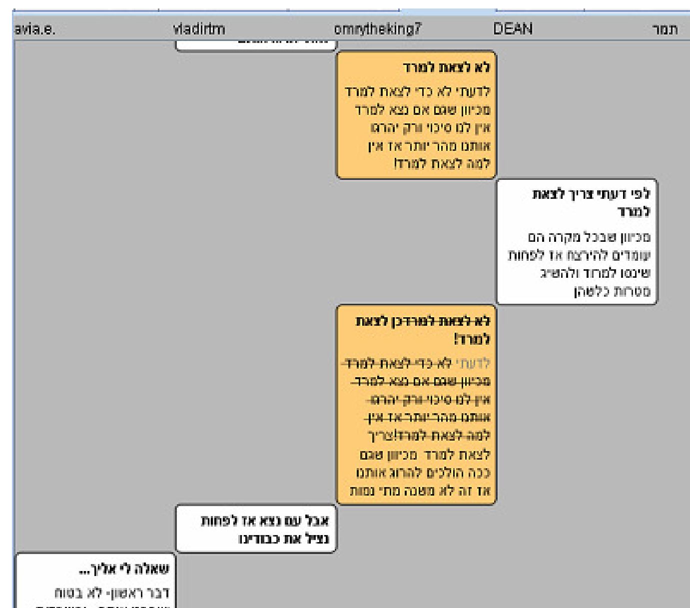

Figure 13: A change of opinion pattern shown in the Chat Table

Figure 13 presents an example of opinion change from an authentic Israeli school role-play discussion, revolving around the question of whether the Jews in a certain ghetto should have revolted against the Nazis. Looking at the central column, that representing the actions of "omritheking7", we see two highlighted "bubbles" (they are highlighted because I selected one of them, automatically bringing to my attention other content-altering actions performed on it). At first, "omritheking7" created a shape arguing against the revolt, since "even if we do revolt, we have no chance and they will only kill us faster, so there's no point in revolting!" Shortly afterwards, "omritheking7" edited the same shape, as can be seen in the lower highlighted "bubble". The updated content reflects an opposite argument, in favor of the revolt, since "they are going to kill us anyway so it doesn't matter when we die". The Chat Table representation makes it very salient that the only addition to the discussion between the time that "omritheking7" wrote his original contribution and the time that he edited it, is a contribution by "DEAN", arguing in favor of a revolt, "since they are going to be murdered anyway, so they should at least try to revolt and achieve some goals." Despite the non-linear nature of Digalo discussions, it is reasonable to assume, after verifying it by checking the previous actions of others in the discussion environment), that the change of opinion by "omritheking7" was contingent upon the contribution of "DEAN" to the discussion.

A second limitation of the clustering approach presented here is it perhaps does not give enough attention to the roles and progress of any specific individual within the discussion, particularly when it comes to content area knowledge. If a similar methodology is to be used by teachers to evaluate the discussion maps of their students, it can prove to be quite a disadvantage, since evaluation in the school context is often student-specific and content-specific, and teachers working with Digalo seem to be particularly interested in feedback regarding the individual actions and achievements of discussants within the group[40].

A third limitation of the suggested methodology and the specific cluster typology found are their specificity to a particular context, both in terms of discussion topics (e.g., social dilemmas) and in terms of their intrinsic dependency on the affordances of the discussion tool Digalo (e.g., use of ontology, linking patterns). While tailoring a methodology to a specific context of application has its advantages (see above), it hinders its possible application to other contexts.

The following limitations, unlike the previous ones, have to do with the specific typology elaborated here, and are not necessarily limitations of the clustering approach used in order to elaborate it:

- Preliminary attempts to assess the inter-rater reliability of coding according to the particular scheme presented in the findings section were not encouraging. The cluster descriptions should be made clearer and less ambiguous.
- The relationships between the elements composing each cluster (and between the elements of this typology and other relevant units and phenomena) are not fully fleshed out. The scheme should be further refined along these lines as well.
- The typology was formulated and evaluated using a relatively small corpus of maps (39 maps), all within a similar socio-cultural and educational context, all revolving around discussions that were, in essence, social or moral dilemmas (even those that were within the thematic realms of physics, biology, etc.).
- The complexity of some of the patterns discovered makes them less likely candidates for use with Query-By-Example (QBE) methods.

Prospective challenges

The cluster types and examples presented in this paper illustrate the complexity of this holistic, bottom-up approach. The definitions of each cluster type are open to subjective interpretation to at least some extent, which could lead to lower inter-rater reliability measures (as our preliminary indication indeed show). This is the first challenge this approach must overcome in order to achieve some significant results.

Furthermore, the great variety *within* each cluster type (compare, for example, Figure 2 with Figure 3, or Figure 4 with Figure 5) in terms of shape types and numbers as well as link types and linking patterns, and the possible over-lap *between* clusters, might make it harder to apply AI methods to automate this process; Harder, but not necessarily impossible (see Miksatko & McLaren, 2008).

[40] I base this statement on impressions gained during several design workshops and focus groups held during the course of the Argunaut systems' development process, in which I took part, see also Hoppe, De Groot, & Hever (in press).

Another challenge this approach faces has to do with clarifying and elaborating on the relationships between the typology presented here and previous attempts at analyzing Digalo maps (or indeed, any other type of argumentative discussion), with a view to further refinement of the coding scheme. Several such connections were made throughout the discussion, and should, in my view, lead to some adjustments of the coding scheme. Specific areas for refinement were identified in the discussion:

- Re-evaluating the inclusion of "argument + evaluation" and "summary, conclusions and/or decisions" clusters in the coding scheme;
- Re-conceptualization of the "chain of opposition" clusters, reflecting some of the finer distinctions made by Leitão (2000).
- Re-conceptualization of the "clarification following feedback" clusters, reflecting the distinction between the speech act category and pragmatic function of the "feedback" (Baker, 2003).

It may also be that these cluster types, identified in Digalo maps produced within a fairly similar cultural and task contexts, would not appear in the same way in maps produced in different countries and/or different settings (e.g., problem-solving in mathematics, cf. Dreyfus, Hershkowitz, & Schwarz, 2001). As further discussions are analyzed, new cluster types may emerge and current ones may seem less relevant.

Despite these challenges, the holistic approach to clustering is simple and flexible enough to be used by teachers and interested researchers to evaluate Digalo discussion maps by revealing collaborative phenomena which may be of interest to them. Indeed, anyone can use the same approach to create their own, specialized cluster typology. An analysis of maps according to the specific methodology and typology elaborated here has already yielded some interesting, organic examples of collaborative argumentation.

With regard to the other goal of these methodology and typology — the development of innovative AI methods to improve e-moderation – it can be said that it was at least partially achieved. Although some cluster types proved to be too complex, algorithms for the automatic identification of other types were developed (Miksatko & McLaren, 2008). Indeed, two of the cluster types presented above ("chain of opposition" and "clarification following feedback") can already be searched for automatically from within Argunaut's Moderator's Interface (cf. Hoppe, et al., 2008), and alerts can be sent about them on-the-fly to a teacher moderating Digalo discussions via the tool.

On a final note, I would like to add that when viewed in the context of the Argunaut system, the shortcomings of this clustering approach with regard to its narrow scope[41] are ameliorated, at least to some extent. Complementary analyses can be performed automatically by the system and support the evaluation process presented herein (e.g., the Chat Table visualization of the discussion, see Figure 13). Furthermore, the methodology and specific typology suggested here, in particular the cluster types of "shared reasoning including argument and counter-argument", "chain of opposition" and "clarification following feedback", have a great potential of assisting teachers in the task of evaluating such e-discussions in a meaningful and relatively simple way,

[41] I.e. its sole focus on some patterns of interaction, neglecting, for example, factors such as overall participation, content-area knowledge development and evaluation per student.

focusing on the most pertinent level of analysis, that of interaction patterns involving two or more users.

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