

Activity System Transformation with ICT: the Case of Argument Diagramming in Logic

Federico Ferrero
Universidad Nacional de Córdoba
CONICET – Grupo Stellae
Córdoba, Argentina
federicojferrero@gmail.com

Adriana Gewerc
Universidad de Santiago de
Compostela - Grupo Stellae
Santiago de Compostela, España
adriana.gewerc@gmail.com

Diego Letzen
Facultad de Filosofía y Humanidades
Universidad Nacional de Córdoba
Córdoba, Argentina
dletzen@gmail.com

Abstract— The goal of this article is to understand the development and transformation of an argument diagramming activity system that uses specific software in "Informal Logic" university classes (School of Philosophy and Humanities, National University of Cordoba, Argentina). From a qualitative perspective, a study case is conducted considering two methodological instances: classes observations and in-depth interviews with students. Specifically, the research describes the activity system established to diagramming arguments with "Araucaria" software and, from there, shows the systemic perturbations that occur in it. Then, it introduces a new technologically possible diagrammatic system that attempts to overcome the tensions warned and to stimulate new reasoning ways. The main finding indicates that the modification of the argument diagramming system enabled by the inclusion of digital technologies (Network Analysis Software) transforms students' learning practices. In particular, their metacognitive activity is enriched by the fact that the new diagrams show the social dimension of argumentation in a renewed and plural way. Thus, the perturbations analyzed at the beginning can be solved when both the object and the motivation of the diagrammatic activity are transformed. Consequently, the institution of a different and innovative activity system can be enabled: the reticular diagramming.

Keywords—*learnings, Informal Logic, new technologies, Vygotskian approach, argument diagramming*

I. INTRODUCTION

This research aims to analyze the development and transformation of an argument diagramming activity system that uses specific software in "Informal Logic" university classes (School of Philosophy and Humanities, National University of Cordoba, Argentina).

From the Sociocultural Approach in Learning Theories, the study addresses recent advances in the Activity Theory [1] [2] [3] [4] to explore how the use of software contributes to diagramming arguments according to the actors' perspective who are involved in the learning situation. That is to say, the question addresses the type of practices promoted by educational software, and the ways in which participants adopt (and/or resist) it in a situated and complex social setting [5] [6] [7].

Assuming this perspective, the challenge is to avoid some obstacles documented in previous research devoted to Educational Technology. In general, these studies not only warn opportunities but also difficulties around the teaching activity that incorporate digital technologies [8] [9] [10]. Specifically, they mention some problematic trends: decontextualized approaches to the uses of technologies,

analysis anchored in tools classifications defined by *ad hoc* categories, little specificity in the reflection on educational possibilities, a certain oversize of the ICT technical characteristics, among others (see criticism in [11] [12]). There is even mention of a certain propensity to formulate research questions based on linear models of cause and effect that address simplistically the benefits of ICT over learnings [13].

Against this background, this study proposes an analysis oriented from the Activity Theory on the ICT use for the learning of a given knowledge object (the diagramming of arguments) in a particular university context.

In accordance with these purposes, we first briefly present the main theoretical postulates of the Sociocultural Approach in Learning Theories and the principles established by Engeström in his Activity Theory developments. Secondly, we describe the study case: an argument diagramming system with the Araucaria¹ software in Informal Logic university classes. Third, we present the methodology used in the study case: classroom observations and, later, "self-confrontation" interviews. Fourth, the results of the research will be arranged according to three moments: 1) the systemic disturbances detected when students diagram with Araucaria; 2) the consequent proposal of systemic transformation to overcome the contradictions found and; 3) the testing of the new diagramming system from a situated approach. Finally, in the conclusions, we summarize the effective transformation of the initial activity system and, hence, the start-up of a new one that uses Networks Analysis Software to diagram arguments in a novel way.

¹ Araucaria is a software application that adopts the arboreal system of argument representation. This program of argument diagramming has been oriented to argumentation in philosophy, law, and science since it was developed in 2003 by Rowe and Reed at the University of Dundee. Among the benefits, Araucaria makes possible to depict inferential relations in serial, convergent (independent supports) or linked structures (dependent supports). It also allows the diagramming of arguments following different theoretical models ("Standard", "Toulmin" and "Wigmore"). Additionally, it includes the option of incorporating types of argument schemes to assess the nature of inferential links. From there, Araucaria offers a set of critical questions or derived requirements that make it possible for an argument to be evaluated according to the conditions of the specified scheme [14].

II. THE SOCIOCULTURAL APPROACH IN THEORIES OF LEARNING

The proposal of a "situational" or "contextualist" turn defended by the theorists of the Sociocultural Approach establishes clear distances with respect to other theoretical bodies dedicated, also, to the study of learnings [15].

Unlike classical cognitive perspectives and behavioral approaches (see criticisms in [16] [17]), the Sociocultural tradition has considered that the "individual" is an insufficient unit to capture her/his learning processes. At the same time, the "subject" definition should not be understood in a substantial or fixed way. Indeed, the position of Vygotsky himself is based on a theoretical core that can be summarized, following Wertsch [17], around three central themes:

the belief in the genetic or evolutionary method; 2) the thesis that higher psychological processes have their origin in social processes and 3) the thesis that mental processes can be understood only by understanding the instruments and signs that act as mediators (p. 32).

In this framework, the Vygotskian analytical unit is defined as the "semiotically mediated intersubjective activity" according to a set of theoretic-methodologic assumptions that have clear effects on the investigative task [18] [19].

However, this approach admits variations of the original analytical unit considering conceptual developments that emphasize different elements and relationships. One of the most recent comes from a group of authors whose investigations are inscribed in the Activity Theory as we know it today. As Engeström [2] indicates, these groups have been working about two persistent topics in the tradition: the scale amplitude and the diversity (according to a model of progress different from its evolutionary, unique, and teleological version).

Inscribed in the context of these challenges, the Yrjö Engeström's developments [1] [2] [3] [4] take the legacy and concerns of the discussions established around the Leontiev's contributions. Specifically, he reviews the category "activity" including more elements to the classic triangular system (subject - mediating instrument - object). Thus, the triangle is finally understood as the "tip of the iceberg" of the analytic unit.

In Learning by Expanding [4] Engeström presents the collective elements of the activity system adding dimensions related to the "community", the "rules" and the "division of labor". From there, the classic Vygotskian triangle [18] is based on a floor that incorporates the community whose practices are organized according to certain rules. Following Cole and Engeström [20], these rules are understood as "the norms and sanctions that specify and regulate the correct procedures expected and the acceptable interactions among the participants"; and the division of labor is defined as "the distribution, constantly negotiated, of tasks, powers and responsibilities among those who participate in the system of activities" (p. 30).

This subsoil in the analytical unit is the one that, finally, includes new elements and relationships whose study allows the understanding of the activity systems from a broader definition of the scale. Simultaneously, this new approach

recognizes the systemic history and overcomes the traditional synchronous analysis of operations with mediating instruments.

Likewise, Engeström [2] establishes a series of Activity Theory principles: (1) the whole activity system is taken as an analytical unit and the consideration of only some elements and/or relations is not enough; (2) the activity system is characterized by its multi-vocality, by the expression of the involved actors' different perspectives; (3) the activity system can be understood historically, that is, in its transformation process; (4) the internal contradictions of the system have a central role as they are sources of development; and (5) the possibility of transforming the activity system occurs in expansive cycles.

We are interested in briefly reviewing the last two principles.

In relation to the fourth principle, the "living" character of the analytic unit -in opposition to its "fossilized" image according to Vygotsky [18]- finds in the internal contradictions the force of systemic change. The notion of "disturbances" -understood as "deviations from the standard script of practices" [1] (p. 964)- indicates that the systemic lives are contradictory and discontinuous. So, to grasp the vitality of the analytic unit means to pursue expressive configurations of systemic contradictions that could motorize transformations.

Based on this commitment, the fifth principle proposed by Engeström refers to the process of qualitative systemic transformation according to the metaphor of "expansion". This is an image that "lies down" the development processes in the sense that traditional vertical progress (by stages arranged consecutively), gives way to processes of "border expansion" in the activity system. That means that the possibility of expansive transformations is defined by synthetic efforts to overcome the accumulated contradictions according to a non-classical model of progress.

In particular, the "expansive cycle" begins with a questioning by individuals or groups to consecrated practice. The aggravation of the conflict is fundamental to motorize a collective transformative movement that crystallizes when two conditions are completed. Engeström points out: "An expansive transformation is achieved when the object and motive of the activity are reconceptualized to embrace a radically broader horizon of possibilities in relation to the previous mode of activity" [2] (p. 137). It is affirmed, in short, that a complete cycle of expansive transformation can be understood as a "collective journey through the zone of proximal development" of the system as a whole.

III. THE CASE: AN ARGUMENT DIAGRAMMING SYSTEM WITH ARAUCARIA

The diagramming practice in Informal Logic allows making easily visible both the inferential relations between statements, and the structuralist character that is granted to the arguments (that is, the assumption of they have an underlying structure or "form" independent, besides, of their content).

In our case, the diagramming with software at university assumes these motives and it will be, from now on, the activity system object of specification and analysis.

In particular, in our study case, there are 13 students whose semiotic and instrumentally mediated activity is directed, with the professor's support, to the diagramming of arguments (Figure 1). This activity system is only understandable if are also considered the rules that organize it, the communities that regulate it, the typical division of labor in a higher education institution and, the special incorporation of an argumentative diagramming software as a mediating instrument.

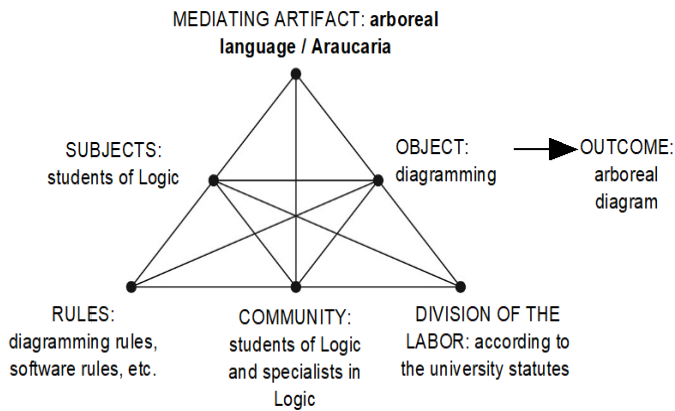


Fig. 1. Diagrammatic activity system with Araucaria. Source: authors' own elaboration based on Engeström [4]

In reference to the rules, we take specifically those that order the main diagramming languages. Among them, one of the most traditional and powerful methods to analyze argumentative passages and to show diagrammatically their structure is known as "arboreal". Strictly, this diagramming method develops a system for the representation of arguments with a branched shape. Indeed, it requires the distribution of circles for each proposition and its union with arrows to designate the inferential relations detected [21]. It is thus possible to construct a diagram in whose base the node corresponding to the final conclusion is located.

It should also be noted that, although this diagramming language has been historically practiced with traditional technologies (such as with pencil and paper and blackboards); we currently find numerous software applications that adopt it [22]. The important thing is to point out that almost without exception, each of these tools proposes a similar procedure: the user must introduce the argument to analyze, differentiate the premises and the conclusion and draw lines that represent the logical links. Following this same sequence, in the specific case of the activity system that we study, the Informal Logic classes are developed around the domain of an extended software application that adopts the arboreal representation system: [14] (Figure 2).

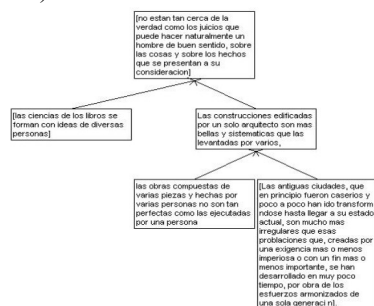


Fig. 2. Example of an argument diagram made with Araucaria

IV. METHODOLOGY

This research is approached according to the theoretical-methodological principles of a study case. For this reason, it has been necessary to locate an interesting "individual analysis unit" with clearly delimited boundaries. After that, we consider an intense and in-depth treatment that recognizes the importance of the context in which the case develops and that is constitutive of it [23]. Indeed, the analysis carried out aims to cover the complexity of the particular case from an interpretative or qualitative perspective in research [24].

In this context, the fieldwork unfolds in two instances: classes observation, and then in-depth interviews with students.

A. Observation of Classes

During a semester, 11 practical 2-hour classes were observed and recorded. Seven of them were dedicated to the use of Araucaria for argument diagramming. From this set of classes, we obtained a *corpus* with the transcriptions of the verbal exchanges between 13 students, a professor and an assistant met in a computer classroom.

The data analysis was preeminently qualitative: analysis of semantic content was carried out applying the conceptual saturation principle for the generation of relevant dimensions and categories to be deepened. The identification and marking of speaking-turns in the transcribed classes were carried out according to an own coding system (for example: "[B-T34]" indicates the number 34 of statements in the second class or B).

B. Self-Confrontation Interviews

From the class observation analysis, a series of hypotheses were set to be tested in interviews aligned with the focus on situated cognition.

We opted for in-depth interviews in which the interviewees confront with different materials (diagrams) and with other subjects in order to settle diverse analysis levels linked to the Vygotskian notion of "make conscious" [19].

For this purpose, the self-confrontation interview device developed by Yves Clot and his group was recuperated and adapted [25].

This "co-analysis" methodology includes a researcher and a subject to whom it is proposed to clarify the issues that arise in the development of her/his activities presented with audiovisual records. Its purpose is to observe and analyze both the own activity and that of others in order to produce transformations of the practices. As it is noticed, although it is an interview technique inscribed in the line of the Professional Didactics -developed for the specific formation in labor situations-, we sustain here that it can be perfectly adapted for its use with students in the context of classroom.

Specifically, two in-depth interviews (recorded on video and audio) were conducted with three students members of the study case, that is, students who attended Informal Logic classes. One of the interviews was realized with "Mark" and another one with "Alexandra" and "John". The transcripts of these interviews were established in numbered speaking-turns (for example: "([T116] A)" designates the turn number 116 enunciated by Alexandra).

V. RESULTS

A. The problem detected: systemic disturbances

The activity system with Araucaria requires technical knowledge development and allows the efficiency in diagrammatic manipulation; however, it is interesting to dwell on the obstacles that hinder the activity. In particular, the interactions analysis between the students and the software reveals some "impossible actions" of typical repetition during the classes. These actions include the explicit references that students make about the limits of software design and what we have conceptualized as "disturbances" in the diagramming activity system.

In effect, disturbances are detected 29 times during the classes under analysis. That is the cases in which deviations occur with respect to the script prescribed by consecrated practice. In addition, persistent automation demands on the resolution of diagrammatic exercises are observed. This means that the students expect Araucaria to provide them with an evaluation of the diagrammatic activity carried out or, failing that, that the application suggests the keys to solve the exercises. Consequently, in the face of the tool inability to respond to these demands, the justification for its use weakens and a kind of "nonsense" in the practice arises.

As can be seen in Table 1, when each new thematic core is addressed during the semester, the unresolved demand appears. For arboreal diagramming, students expect the program to automatically identify the inferential steps (see Table 1, section 1) or to evaluate the diagram entered (section 2). In the diagramming of arguments types, the students do not seem satisfied with the graphic marks with which the software differentiates the diagramming structures (fragment 3). Much less, students approve the response obtained considering their expectation that the tool identifies by itself the typology (fragment 4). The diagramming of arguments according to the Toulmin model also shows the unsatisfied demand for automatic resolution (fragment 5). Finally, the dialogical diagramming finds that the output is only a graphic mark over the arguments to identify each party involved in the dispute (fragment 6).

TABLE I. DISTURBANCES DURING CLASSES OF INFORMAL LOGIC WITH ARAUCARIA

#	Exemplary class fragments	Thematic core
1	[A-T43] PROFESSOR: Because the arrow goes from the premise to the conclusion, then, the idea is that now we see where the arrow is going... well, what do you think? (laughs) What is the premise and what is the conclusion? (laughs) Of course, the program does not do that anymore! It's to diagram nothing more ...	Tree diagramming
2	[B-T49] STUDENT: The program does not tell you if it's right or wrong. That is a defect.	Tree diagramming
3	[G-T117] STUDENT: Ah! Does it just give you the title? [G-T118] PROFESSOR: Sure, it labels the type of argument that it is (laughs).	Types of arguments diagramming
4	[G-T88] PROFESSOR: And from there you go back to the scheme... Select... what kind of argument is it? (the student looks at her and laughs). That's what you have to think! (laughs) What kind of argument is it?...	Types of arguments diagramming

5	[J-T54] PROFESSOR: Oh, yes, of course ... it does not do it alone ... This is still the same, even though ... Even if they are in Toulmin ... [J-T55] STUDENT: Oh! I thought Toulmin was doing the work for us...	Diagramming according to the Toulmin model
6	[J-T388] STUDENT: And in the other, in the little box that says "this is ridiculous coming from you" ... (the teacher agrees). Of course, it's just that ... (disappointed with the outcome). [J-T389] PROFESSOR: Yes ... no, no, it was not so ... (laughs). [J-T390] STUDENT: But there's no way... [J-T391] STUDENT: ...How to make them fight (laughs). [J-T392] STUDENT: Sure! I want you to fight. [J-T393] PROFESSOR: And... no... because the two come to different conclusions. They will not achieve the same. [J-T394] STUDENT: Very bad.	Diagramming according to the dialogical model

a. Source: authors' own elaboration.

Even, in certain opportunities, the students propose the substitution of the technology as a general reflection when the Araucaria limitations are noticed. They say about it: "It's better when you have a sheet ..." [B-T61]; "If we had pencil and paper, none of this would be happening ..." [J-T192]; "Is the same than a good paper sheet... (ironically)" [J-T398].

In light of these statements collected during the semester, the pencil and paper option seems to offer benefits as powerful as those provided by Araucaria. In effect, it is pertinent here to consider an event that occurred during the fourth class. On that occasion, a student brought a diagramming homework using a word processor software: "(...) I did the exercises in Word, Can I deliver them like this?" [D-T56].

The event is relevant in this context because for the student it was perfectly conceivable to opt for another digital tool that replaces the recommended diagramming software. The question arises about technological interchangeability: do students consider that diagramming with Araucaria, with pencil and paper or with a regular word-processor software are equivalent experiences? Obviously, from the students' point of view, the unfulfilled expectations when using Araucaria dilute the existence of its "exclusive benefits".

The indicated inability to provide innovation seems to respond to a problem of software design and its systemic insertion: both the contents and the traditional motives that define the diagramming activity system are reproduced.

As it has been well documented in other investigations [26] [27] [28]; our findings not only show that the mere incorporation of ICT is insufficient to improve practices, but also that their inclusion, sometimes, adds inconveniences (in line with the results obtained by Lantz-Andersson [11]).

When examining the analytical unit with more precision, we observed that the expression of systemic perturbances takes place in the line that links the mediating instrument, the subjects that use it, and the rules that the same software sets (especially in terms of diagrammatic language). As a result, it is possible to hypothesize that detected perturbations are established due to the "transfer" of a classical (arboreal) diagramming system to a virtual environment in which the transformation of this content does not occur. The innovation of the diagramming practices will require, then, the development and study of

another diagramming language constructed with digital technologies. Therefore, it is expected the proposal of an alternative diagramming system that allows recreating different ways of thinking, unlike the classic arboreal choice.

B. Proposal for systemic transformation

The need to transfer the attention from the software to the diagrammatic languages requires the development of new graphs whose inclusion in an activity system allows to overcome the detected perturbations. In effect, we have proposed the development of an activity with a new class of diagrams: the "propositional networks" (different, but coming from the classical argument trees).

To do this, software applications such as Ucinet and Gephi have been used to examine data in accordance with the principles of Network Analysis. It is necessary to point out that although these tools find multiple applications in the educational field to analyze groups and their interactions [29]; in our project we use them to obtain graphs that juxtapose argument diagrams constructed individually by the students. The purpose of this conversion is to generate reticular diagrams that make it possible to summarize the way in which a group of students visualizes the structure of a certain argument.

In this research, a group of tree-shaped diagrams elaborated with Araucaria has been recovered. Afterward, these arboreal diagrams were entered into Ucinet software in order to juxtapose them. So, on this occasion, the main sources of information were the 13 arboreal diagrams developed with Araucaria by the students of the case (Figure 3).

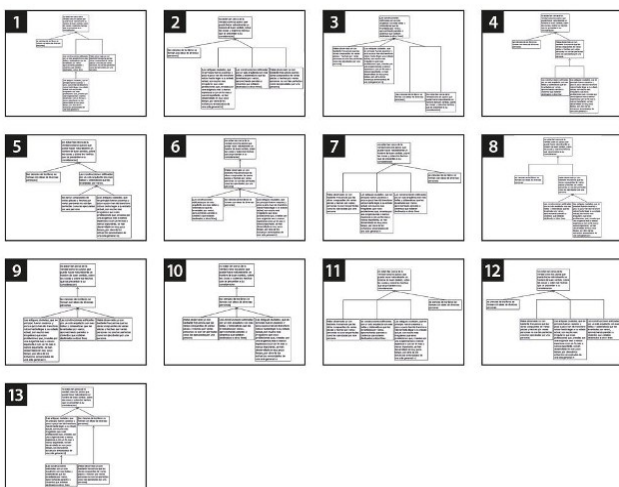


Fig. 3. 13 diagrams for the "Descartes' argument" built with Araucaria in the classroom

From there, a new and unique diagram constructed by coupling or juxtaposition was generated. In this research, it is called "propositional network" (Figure 4) and expresses, in summary, the way in which the group of 13 students visualized the argument logic structure.

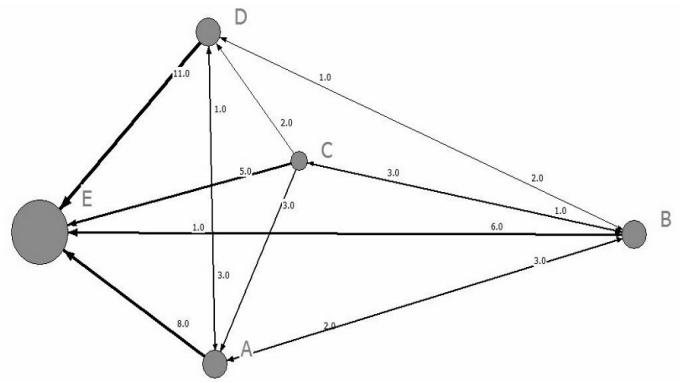


Fig. 4. "Descartes argument" network built with Ucinet by superposition of 13 diagrams elaborated individually with Araucaria

In the network diagram, the nodes correspond to the propositions and the arrows to the inferential assignments. We also incorporated two graphic marks: 1) different line thicknesses for the vectors that indicate with small numbers the recurrence of each inferential relation; and 2) the size distinction of each node in proportion to the number of receptions achieved. For example, as can be seen in the image of the network (Figure 4), 11 students have admitted that proposition E is logically inferred from proposition D. Therefore, the premise E is the one that more inferential support has received in the diagrammatic analyzed session.

As a consequence, the modification of the diagramming activity system includes a new mediating artefact: no longer the "arboreal" language used in Araucaria, but the "reticular" one. Thus, the subjects' activity is mediated by a new diagramming language: that of the propositional networks (Figure 5).

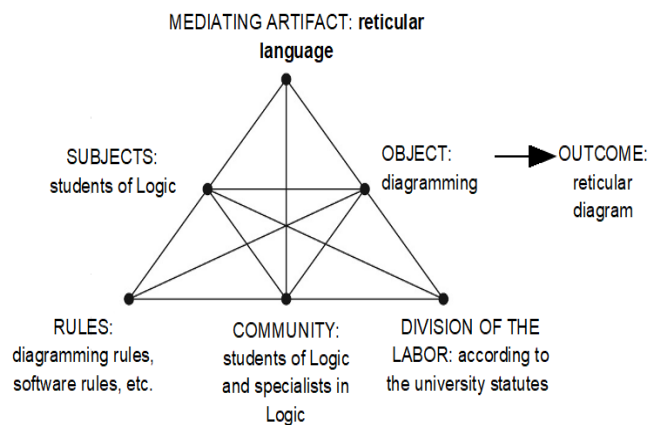


Fig. 5. Diagrammatic activity system with propositional networks. Source: authors' own elaboration based on Engeström [4]

C. Testing networks from the Sociocultural approach

The next challenge is to explore if new ways of thinking are recreated when the systemic modifications we have formulated occur. Thus, from now on, the interpretations and reflections made by the students will be analyzed when the propositional networks are presented as analytical materials.

Social manifestation of argumentation: inferential recurrence

Unlike arboreal diagrams -where each graph represents a personal extraction that each student makes of the logical structure of the analyzed argument-; the networks make it possible to visualize the diagrammatic production of a reasoners group. Because of this disposition, the reticular graph motivates metacognitive reflections when it is read the production of the group. That implies a knowledge about the cognition of the group, a way of accessing "how a certain group of reasoners thinks" the structure of a determined argument.

In this sense, Mark, in the self-confrontation interview, argues that the network could be inserted in "a more sociological study" given that it is useful for the professor to "see how their students think in general the inferential relations" ([T109] M).

In the same line, the following interventions emphasize the tactical possibility for the interpretation of social production when the networks are used.

([T81] M) (...) As... more detailed these... (indicates tree diagrams). But here (network diagram)... you can see it with the naked eye, let's say. For example, most agree that this, that E, or that node E is the conclusion. While here (the arboreal diagrams) I have to read one by one to see if they believe that this is the conclusion (...).

([T116] A) It is interesting to the extent that (the network) collects all the others and that seems to me to be very good... and that it can be visualized much more quickly than looking at each of these (individual diagrams) and comparing...

Considering these interventions, it is evident that the diagrammatic appreciation at a social level is favored by the networks. But how does this analysis occur with greater precision?

As noted, the repetition in the inferential relations assignment is captured by the vectors that take different thicknesses according to how many reasoners admit the existence of logical ties (Figure 4). Moreover, the numbers in the networks indicate how many students have recognized the different inferential relations.

The interesting thing is that, from the interviewees' point of view, the knowledge produced about group cognition implies understanding recurrence as the support of a certain logical legitimacy. Indeed, after the interviewer presented the hypothesis that "the most recurrent relations have a more legitimate logical meaning" ([T67] E), the students pointed out:

([T68] J) Sure.

([T69] A) (nods) And ... to the extent that there are more people who think that's that. There (networks) collects different opinions.

However, the attribution of "logical legitimacy" from inferential recurrence is not an easy or unanimous assumption. In the other interview, Mark affirms the need to clarify who are the people whose graphics gave rise to the network.

([T95] M) (...) To be consistent with me, there is an argument fallacy called *ad populum*, which

indicates that no matter how much the majority tells you something is like that, it does not prove the validity or invalidity of the argument. But in this particular case, we are talking about philosophy (students) that (laughs), one could say that ... they could slightly become an authority... if you will... That is to say ... and it depends on who says it basically...

This more refined observation aims to think about the interpretation of recurrences with some caution. With the *ad populum* fallacy -which can be considered as a universal affirmation about cognitions-, it is possible to relativize the idea of recurrence to designate logical legitimacy. Only when it can be shown that reasoners are considered "authorities" in the matter, total relevance can be given to inferential recurrences. In any case, the inferential assignments made by the students provide interesting and valuable data on the everyday-life reasonings that often differ from the experts' performances.

Findings such as these are suggestive since they place the problematic of epistemic legitimization on the front page. Unlike what happens with Araucaria, in the reticular system, the legitimization of knowledge is not based on the criterion of authority (Logic experts), but rather on popularity rules which are also key organizers in other contexts such as social networks and online environments [27].

Network diagrams: non-negotiated and polyphonic social representation

The characterization of social thinking expressed in networks requires the pondering of the juxtaposition as its organizing operation.

As it has been pointed out, the reticular "product" is not equal to the sum of the individualities but, rather, to an overlapping set in which it can not be distinguished each one of the students who diagram. In this sense, we say that the network represents a set of thinkings practices that do not have an identifiable agent: a "social abstract" representation with the ability to, taking John's words, "collect a large amount of data and, in turn, none" ([T296] J).

An observation like this can give rise to some comments related to the meaning that "the social" has in the reticular structures.

In this respect, it is known that the category of "group" - and more recently its development in terms of "collaborative work" - is usually linked to the idea of an interactive structure whose decisions are defined as individual products negotiated by all the members of the team. That is, the approach of group work as if this should be aimed at achieving a "total intersubjectivity" established when all the actors agree on the definition of a situation [30]. It is interesting to note that this conception is not strange for the dominant pedagogical tradition since what is prescribed for group construction is, in general, a vision agreed by all the team members: an individual version that represents the group.

Now, in the case of propositional networks, it is evident that each of them juxtaposes individual visions of an argument without summarizing them in a single negotiated structure. In effect, we have here another sense for the category "collaborative" as the reticular graph is actually a diagram that neither represents inferential paths agreed and

negotiated by all, nor the individual diagram of any of those who participated in its construction (in the sense that we can not distinguish the set of inferential concessions that each reasoner made).

Following these operation rules, the network diagram would propose a new device different from those in which the group production should aim at achieving an agreement around a single position or -as it is suggested by the Pragma-dialectic of van Eemeren and Grootendorst [31]- the "resolution of a conflict of opinion" in which all members agree.

As noted, the reticular reading goes further and implies the identification of argumentative movements whose producers have been "lost". It implies to understand the logical consistency of the different positions in a conglomerate of multiple, diverse, and sometimes opposite inferential relations that express a certain "polyphony" [32] when reading the argument.

To mark the contrast, it is very different, for example, the argumental device of the debate usually practiced in the classroom [33] [34] [35]. In the debate, opposing positions are well individualized (either the own point of view or that of the adversary) in an interactive situation where only one of them wins in the discussion or, in more extreme cases, imposes a "winning" perspective. The operation of this device is, in the bases, justificationist of a unique point of view since among a variety of options, the best one should be established in order to conclude the debate. The interesting thing is that, as the Deanna Khun's school debate studies [35] show, interactive dialogical scenarios do not guarantee the approach to the opponent's position because in them, often, a recalcitrant hardening of one's own position is noticed.

This happens, for example, when we consider the reading of networks in which some reasoners have indicated an address between two propositions and, others, the direction exactly opposite (see the inferential relation between nodes A and B in Figure 4). That is to say, instances where problematic inferential assignments are observed in the network diagram because there is disagreement about the inferential direction between two determined propositions:

([T99]J) (...) I was trying to understand why there were 2 connections... because I think the correct one is not that. The correct one is that from B to A, these 3 but these do not ... try to understand why there were those connections...

As it happens in these typical formations that we have denominated "bidirectional relations", the points of view in dispute do not necessarily need to arrive by consensus to discard one of the positions. As we have previously shown, students manage to construct serious and solid hypotheses about the different reasoning principles that led to the diagramming of these controversial inferential relations. Therefore, it is constitutive of the network, the exhibition of opinion differences and the understanding of the responses plurality from the logical perspective.

VI. CONCLUSIONS

This study has shown that disturbances appear in the activity system each time a new "thematic core" is presented

for the diagramming with Araucaria. We refer to the fact that there are actions that the software does not automate and that endorse, finally, the attribution of a certain nonsense to its use. From the students' perspective, Araucaria does not seem to offer alternatives to the "traditional" diagramming experience.

All these elements make a conclusion: although the activity system set with Araucaria allows the efficiency in the diagrammatic manipulation, there are no transformation signs of the content to be learned. In other words, the transfer of a classical (arboreal) diagramming system to a virtual environment is observed but, in fact, the transformation of the content itself does not happen.

This working hypothesis sustains, in short, that in the case of the diagrammatic activity system, beyond material technology -or "technical instrument" in Vygotskian jargon-, it is interesting to deepen in the diagramming language or "psychological instrument". This hypothesis tries to recover the specific meaning and the Vygotsky's real interest on the mediating instruments defined as languages [36]. Therefore, it is suggestive that the material technologies studied (e.g. Araucaria) lose strength and, instead, there is a growing interest in the distinctions between different languages of argument diagramming.

As a result of this, a new diagramming language ("reticular"), different but coming from the classic argument trees, is proposed and described. It is hypothesized that the diagramming system with networks gives rise to meta-analytic operations interested in the ways in which a given social group visualizes the argument structures.

By "testing" the propositional networks from a situated perspective, it is observed that, in effect, these novel graphics allow us to work in a renewed way on 1) the social dimension of argumentation and, 2) the plurality in the reconstruction of reasonings. Additionally, the students' interventions in the interviews permit problematizing some classic "argumentation" definitions when two novel ideas enter the discussion: the dialogical singularity manifested as "polyphony", and the vanishing of the justificationist operations from a unique point of view.

These results describe, in summary, *sui generis* thinking practices that network diagrams make possible when they are evaluated in contrast to classical argument trees or other argumentative devices such as debate.

Now, the results itinerary described up to this point allows us to approach the fifth principle of the activity systems as we consider the Engeström's theoretical developments. This is the principle of the expansive cycles that can occur when the object and the motiv of any activity system are re-established.

On the one hand, as regards the object of the analytical unit, the results of this research require a specification for the concept of "diagramming". This distinction is thematized according to "arboreal diagramming" and "reticular diagramming" and, although the operation seems to cover only an adjective strategy, we see substantially transformed the systemic object.

On the other hand, in relation to the systemic motivation, we are in a position to make another important distinction. In the arboreal language, the motive is aimed at extracting

the "underlying" structure of the argument as the reasoner commits to a stable but covert argumental ontology. Meanwhile, the reticular language is oriented to analyze the way in which a group visualizes, in a particular situation, the structure of the argument. In this case, the understanding of the social and plural manifestation in the argumentation is pursued, as much as the metacognitive activity enrichment. Thus, the emphasis in the "functioning" analysis of the networks disputes the essentialism and the identification of "correct" structures as it happens when analyzing the traditional arboreal diagrams.

According to this qualitative transformation of the object and motive, it is finally possible to say that the new diagrammatic language opens possibilities to institute a different model of activity because of its departure from established norms and consecrated practices. In particular, we distinguish two different systems of argument diagramming that do not deny each other, and that are linked because of the new one is structured from the other.

In summary, this study has shown that the transformations of Informal Logic learning practices with new technologies are given by the reconceptualization of the activity system as a whole. With the introduction of new rules of the language that mediates the diagramming processes, is observed a systemic restructuring. Thereby, the diagramming system -at first hindered by internal contradictions and tensions-, finds transformation possibilities when the object and the motivation of the activity are reconverted. This finally allows offering a broader horizon of cognitive possibilities that did not exist in the previous activity mode. In other words, the expansive transformation overcomes the accumulated contradictions in a synthesis movement that progresses through the zone of proximal development of the diagrammatic activity system.

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