PhD Thesis

DIALOGUES IN CYBERNETICS: A MODEL FOR UNDERSTANDING CRITICAL THINKING CONSTRUCTION IN THE DIGITAL AGE

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I will say that critique is the movement by which the subject gives himself the right to question truth on its effects of power and question power on its discourses of truth. (Michel Foucault)

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Abstract

This thesis study examines the Critical Thinking construction from students while using the digital technologies for web-based activities at school. At the end, we propose a model that explains Critical Thinking based on the Science of Cybernetics.

Critical learning opportunities within schools are needed urgently. Critical thinkers will be adaptable to technologies and therefore will present essential qualities for the Digital Age. The scientific literature is full of arguments to support this approach, however, apart from some studies that propose a linear model for this matter, not much has been proposed concerning a complex model for Critical Thinking in the Digital Age.

To this end, the research question is as follows: How is the critical thinking process fostered at the Cognition Level in the Digital Age? This is addressed by considering the process of critical thinking as an open system, according to principles of Cybernetics.

Data for the study was collected twice. The initial Pilot Study revealed unexpected phenomena which current theories in Education could not explain. In the Main Study, a Cybernetic approach was used preserving identical research techniques and data analysis instruments from the initial study. Both studies used a Research Protocol Activity executed by participants and, after that, a clinical interview. Data were analysed and a Cybernetic Model for Critical Thinking proposed, applying the principles of Entropy and of Selective Retention, to explain how critical thinking is built in the Cognitive level. The Model has been built from the exploratory Pilot Study and the Main Theoretical Study.

This thesis presents the background of Critical Thinking, with a theory and concepts that will help to stimulate critical thoughts, suggesting the path that must be taken to stimulate and develop critical thinking in students. This work has a significant contribution to the existing critical thinking literature, proposing a holistic approach that includes Cybernetics and Cognition. The developed concepts of "Entropy", "Deterrence", and the Model itself can help assessing learning and cognition in another dimension. We proposed the concept of Entropy to critical thinking (see Chapter 5) fostered from a large literature review that involved Philosophy, Sociology, Education and Cybernetics. The concept will be helpful to researchers who want to dedicate their project to cognitive phenomena, or to Human-machine interaction. Similarly, the concept of Deterrence can equally be used for areas where cognition, education society and Cybernetics can be helpful.

However, further work is needed to extend this study for other populations, such as adults and university undergraduates. By validating the model in such populations, it could be successfully applied to foster critical thinking in most human beings, while involving digital technologies.

Keywords: Critical Thinking, Cognition, Cybernetics, Digital Age

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INTRODUCTION

Introduction

1.1.   Context for the Study and research questions

Bauman (2013) has used the term 'Liquid Times' to refer to the Postmodern Era, the Digital Age where everything is unstable and changes are needed throughout society, including in schools where there has been much effort in recent years to make them 'digitally included'. Similarly, as noted by Cazeloto (2014), in the Digital Age, "digital technologies submit society to their necessities, creating specific forms of being and occupying the world, as well as human relationships which are attached to the computer screens mediation".

The availability of knowledge in this 'information age' brings the need of evaluating information, frequently discarding what is not relevant. Information needs to be relevant and reliable in order to produce suitable knowledge (Demo, 2014, p.04). Therefore, it is important to understand how effective discernment of knowledge can be fostered at schools, creating critical learning opportunities as an urgent need. Critical thinkers are more adaptable (Foreman, 2003), creative and excellent examiners, being essential elements for the Digital Age, once they can work with learning and memory, problem solving, being critical, and educationally main issues, like Ethics.

The use of technology in schools does not guarantee inclusion in a social context with technological literacy. Studies investigating the use of technologies in schools suggest that the use of technological resources at school must be linked to a coherent approach, which brings the student to the centre of the process of producing knowledge, not just reproducing what has already been made (Shepard, 2000).

Theorists who advocate the use of classroom technologies suggest a possible solution: lessons organised from general and multidisciplinary themes, and students working on projects that involve meaning, content and challenging proposals to develop the superior skills of analysis, interpretation and design (Becker, 2008). In this case, the use of technologies can play an important role in this scenario, presenting activities to students involving the creation and development of final products to the society beyond their classrooms, providing to students the tools used in society as usual. Access to that teaching perspective of ideal and

meaningful learning means using all content produced by students from the school to the community around it, such as image editors, movie makers, recording, social media, videoblogging, & producing, and not only the use of text editors for mechanical research in the classroom.

The apparent success of the use of digital technologies (Merchant, 2012) in the classroom brings a new educational paradigm and a concern: if digital technologies are an emancipatory practice for the students, with production and questioning contents, why not use this technology to produce relevant individual content? Why is the level of criticism and research production - even in schools - still so weak (McPeck, 2016)?

Schools and the general education system still expect to deal with the same groups of students found in the past, in which they reproduce the same attitudes and behaviours of previous generations. Students bring to school elements from digital culture, but these are not part of school culture, yet. Some can argue there are enough digital devices at schools, at the moment, but the truth is just technologies "being there" does not bring relevant elements to change school culture, and the way how teachers and students move around these technologies. For some reasons, the digital revolution has remained outside the schools' walls, as children know it. The activities we have at schools could be easily done with paper and pen. Moreover, it would be desirable that the Web 2.0 environment could offer, from the variety of its elements and networks, by interactivity, an environment favourable to the emergence of critical thinking by students, albeit incipient. It is not possible observe, in 2018, a relevant movement on changing schools conceptions to put in evidence the student's authorship (not merely reproductive) required from Digital Age. Critical thinking is the result of a dialectical movement between analysis and judgment, evaluating the consistency of discourses, especially the statements that society considers as the truth in the context of everyday life (Facione, 2000).

The interaction through social networks, the internet in general and through collaborative learning, has been widely explored in academic research (Livingstone, 2004; Castells, 2015). It is known also that students prefer to use their own devices to support learning also using their network on social media to learn (Parslow et al, 2008). More than ever, schools need to stop thinking of digital devices as "showcases" which "expose" materials and photos, and start seeing them as an effective tool to communicate, understandable to young people.

Some researchers have explored aspects of the use of software and participation in social networks, programming and editing, and the direct relationship with educational and social aspects explored in social networks (Ellison et al 2007; Valle, 2011). Building skills and sharing knowledge are key components of this type of literacy. People have to discover, evaluate, synthesize, serve and share information and knowledge from initial information in order to solve complex problems. These skills are of fundamental importance for the success and inclusion in the knowledge economy in the new-networked world. With other literacies required in today's world and life with its competences such as digital literacy, critical thinking skills and production and consumption of knowledge (Livingstone, 2002), the use of social software and virtual worlds needs and fosters new types of interactions and readings, such as reading images (Bamford, 2003) and skills in the use of digital devices and products. Many of these interaction and critical practices defy conventional standards of knowledge production and consumption, as well as placing knowledge in educational institutions.

Being critical means to be ready to recognize faulty arguments, hasty generalizations without evidence statements, ambiguous or obscure concepts, and so on. Most people need to exercise their critical faculties and question the logic of arguments of most daily activities. "The art of explaining, analysing and evaluating these arguments and logic is essential for the development of critical literacy skills" (Facione, 2000, p. 04). Formal and informal logic skills are at the heart of qualities needed to exercise critical thinking, as well as conceptual and epistemological analysis. The main objective in developing critical thinking is to override superficial or distorted thinking, bringing to the surface thoughts based on research and analysis processes. In the tradition of critical reflection, as stated by Facione, critical thinking aims at self-sufficiency.

1.2 Relevance of the Study

Being critical, especially in the digital age, is like being a researcher of information: the person is led to look for reasons and evidence of a particular argument. This begins when we exercise mastery over certain thinking skills: learn to perceive forms of invalid argument, defend distinctions, look for invalid or false sources of information, etc. Some authors (Almeida, 2003; Facione, 2000) have recognized that the traditional curriculum content and

its associated "skills" are not taking due account of the students' inclinations to look at the world through a critical lens. So, being critical means not only having the skills to think with criticism, but knowing the need to validate the arguments by scientific search. For example, Facione states that a critical person not only needs to search and analyse arguments and stay well informed, but also to have a predisposition to do these things (ibid).

Concern for critical learning spaces within schools emerges in the digital generation, as an urgent need. Critical thinkers will be more adaptable to technologies and therefore the most likely to succeed in their activities. John Dewey, in his studies, has emphasised the need for reconstruction of everyday school practice, suggesting that we should abandon the old and "new" models and work on a reflective philosophy of educational practice (Dewey, 2007). This discussion seems to take shape as the information analysis skills are directly related to critical thinking. They have been discussed in at the beginning of Digital Age, but is necessarily a broader approach to these skills, especially because the digital generation is organized and moves differently from previous ones.

1.3 Original Contribution to Knowledge and Practice

Issues relating to understanding and learning have been classified in conventional academic terms, giving a focus to Digital Technologies as a matter just of technology, forgetting to address them as part of a broader understanding of the world. Attempts by current cognitive models in dealing with technology in school have only been able to see it as an instrument, a tool within a larger process, forgetting that we are dealing with the issues in a grander system. The science of Cybernetics seeks to understand the present in an interdisciplinary approach in general particularly residing in human-machine interaction (Levy, 2001; Bauman, 2010). Mainly, we aim to understand how it affects humans and their relationships. This research is aimed at a deeper understanding of critical thinking and technology using the Cybernetics methods.

This study was performed in two steps: a Pilot (2011) and a Main Study (2016). Some concerns exist about the first results of the Pilot Study which were developed during the Researcher's Master degree (Valle and Abranches, 2011). The available understanding originated from a fragmented view of traditional science methods which has not allowed a better understanding of the Critical Thinking phenomena. There were not enough answers

for the phenomena, which will be explained in the "Pilot Study" section. During this research development, it was established as the hypothesis that student interaction with the web-based platforms would form more independent and critical thinkers while a model following the principles of Cybernetics science may explain the development of critical thinking.

The overall objective could be defined as:

- to build a model, under the principles of Cybernetics science, proposing a theory of critical thought to explain how the construction of critical thinking is structured and processed in children, stimulated by interaction with digital technologies and describe how it handles such construction.

- After several years searching for answers, the Researcher found the approach brought from cybernetics seemed to explain the phenomena. The Cybernetics science was the best option to understand and explain these phenomena because of its interdisciplinary character, the holistic view of and broader approach to the phenomena.

It would be important to realise that simply changing school facilities will not guarantee quality teaching. School teachers need to stop thinking about technology as enemies: a teaching concept that allows planning and room for the unexpected element of every research. The resultant model proposes a non-linear classification of critical thinking rather than classifying critical thinking skills from most elementary to deepest "self-regulation". Recognizing that Pask (1976), through his Conversation Theory, has built a strong argument for interaction being necessary to learning, our model proposes that the beginning of intelligent learning resides in interaction, whilst recognising that learning is not just about assimilation of data, but the use of knowledge to change and/or transform situations (Freire, 2005). An Initial Judgement phase follows at which point the student demonstrates the deeper skills of Interpretation, Analysis and Inference. Subsequently, the learner reaches a decision point where the "thinker" can simply retain their critical thinking process or enter what can be considered as "Critical Entropy". Here, the entropy process will disorganize the whole system of thinking, but at the same time will lead the students to the deepest phase of critical thinking.

1.4 Methodology

To develop the research in the field, we propose a research protocol, following the academic rigour that is necessary while dealing with research and human beings. Firstly, we proposed a web-based activity to be executed by students, following a research-methodology to schoolchildren presented by Demo (2015). This author states that "the imitator's attitude prevails among us: we learn to copy, reproduce and bring ready answers to the exams. The attitude of learning through self-elaboration should be stimulated, replacing the curiosity of listening for the production" (ibid, 2015 p.10). The research activity has stimulated the creativity and complexity of student's ideas, bringing some discussion and avoiding ready answers. This led to a research web-based protocol.

The second step was to describe the children's research trajectories, tracing their research steps on the internet. It is important because we need a clear perspective of how the children have built their answers to our research questions. Still, we preserved the use of mobile devices by children when connected to the Internet, assessing the impact on children's cognition.

The third step was identifying the relevant elements of critical thinking in children, while interacting with the platforms and mobile devices. For this, we used the criteria of critical thinking skills proposed by Facione (2015), through Piaget's Clinical Interview adapted to digital devices.

The next step was to analyse and investigate the critical thinking skills present in each child and point out how these thoughts are constructed, fostered by digital technologies. It was important to map the evolution of this thinking, and how every student reacted to the stimulus of the research protocol.

Finally, the skills presented by students should be evaluated under the Cybernetics principles, in order to validate the model proposed after the Pilot study findings. Cybernetics has brought a broader background to understanding how Critical Thinking was presented and built from children's brains. In this case, two principles were fundamental: Entropy (*In order to destroy a stable equilibrium, you need to add energy, and the more stable the configuration, the more energy you will need* – Heylighen, 2007, p02) and the Principle of Selective Retention (*Stable configurations are retained, unstable ones are Eliminated* – p.01)

1.5 Personal Methodological Journey

This is a case study of qualitative approach with epistemological framework and a Constructivist comprehension of learning. This research is applied, qualitative, and explanatory, due to the nature of the field study. The case study needs a rigorous methodological design, starting with a clear definition of the main objectives to solve the problem of explaining how or why a phenomenon takes place. This is explained in detail in the Methodology chapter. The data were collected in the two studies using the same research techniques.

The population on both studies were not the same, and there was a time interval between the data collection of five years. The participants from the Pilot study were from a countryside primary school in a poor region in Brazil (Valle and Abranches, 2011). The participants from the Main Study were located in the fourth-largest urban agglomeration in Brazil, also a poor region in a Secondary School. The Researcher has spent the necessary amount of time for data collection on both schools.

In both studies (Pilot and main) the data were collected in two steps: the performing of the research protocol by participants and, after that, the clinical interview. After the data collection, the software of data organization was used to help on qualitative content analysis. After describing and categorization of interviews, the data were analysed and the production of the Cybernetic Model was done.

1.6 Synopsis of Chapters

This thesis is presented as follows. Chapters 1, 2 and 3 establish the context, background and design for the study, whilst chapters 4, 5 and 6 present the individual and collective accounts and discuss the findings and implications of these.

Chapter 2 introduces the context for this research in the Digital Age. It explores the main society changes related to digital technologies, and how those changes particularly affect children and, consequently, schools. The relationship between school and knowledge changes, schools are not the primary source of formal knowledge for children, anymore: they

have internet. The first section of Chapter 2 brings a background about the Digital Age and Education, what changes at Liquid Times, and what still needs to be clarified. It aims to focus on the current situation of schools dealing with digital devices for an emancipatory education, which would be ideal. The second section explores the concepts involving critical thinking and why it is important, bringing elements like Enlightenment, Habitus and Power; we consider those elements can be decisive to the understanding of critical thinking itself. The main purpose of this section is laying the foundations to build a critical project, leading to the presentation of main critical thinking skills. The third section is a literature review about main aspects of Cybernetics principles and laws, looking at the Cybernetics science as a viable proposal for understanding the changing times.

Chapter 3 presents the research process which was undertaken for this study. It outlines the case study for an explanatory research as the main methodological approach. All decisions taken during the research are explained, also the Pilot Study and Main Study subjects choice process. It also explains the research protocol as a data collection tool, as such as the clinical interview adapted for digital devices. This chapter also presents a discussion on how this information was analysed and organized, which includes the approaches observed in expressed and latent contents. This chapter also outlines the quality criteria applied to the study and explains the ethical issues considerations, pointing the limitations of study.

Chapter 4 presents all the results and discusses the trajectory performed by this study. Accordingly to the critical thinking skills, the data are presented and described. Two categories presented in the Pilot Study have been renamed in response to the Cybernetics approach, after the comprehension we have been facing a complex cybernetics phenomenon.

Chapter 5 presents the Cybernetics Model for Critical Thinking, as the main finding of this research. It outlines the cultural understandings concerning critical thinking and Cyber society, presenting the critical thinking as a System, tracing some considerations about critical thinking use for artificial intelligence.

Chapter 6 presents the conclusions, findings and implications of the study. It summarises how the digital technologies have changed the children and society more than the schools. The research protocol as a school activity could be a good option in the digital age, but still face the challenge of a school working in the same way as in past centuries. The proposed model can help teachers, researchers and developers to understand how critical thinking is fostered, bringing solutions in the same corresponding area.

Chapter 2
Literature Review

Chapter 2 – Literature Review

This chapter provides background to this research on critical thinking in the digital age. It covers three distinct areas which are relevant to this topic. The first section of this chapter brings a background about the Digital Age and Education, what alters in Liquid Times (Bauman, 2013), and what still needs to be clarified. It aims to focus on the current situation of schools dealing with digital devices for an emancipatory education, which would be ideal. The second section explores the concepts involving critical thinking and why is it important, bringing elements like Enlightenment, Habitus and Power; we consider those elements can be decisive to understanding critical thinking itself. The main purpose of this section is to bring the foundations to build a strong critical understanding. The third section is a literature review about the main aspects of Cybernetics principles and laws and looking at the Cybernetics science as a viable proposal for understanding Liquid Times.

2.1 Education and Technology

Cybercultural society is characterized by the upcoming ubiquitous mobility connected with cyberspace and cities (Lévy, 2000). New expressions of citizenship, cultures and authorship have being formed. This section is dedicated to understanding how currently the cybercultural mobility has contributed to shape education, describing events of Cyberculture in mobility times. The epistemology of multiple references and the method of interactive immersion in cyberspace underlie the arguments presented.

Our society faces an experience of impressive cultural emphasis on the "self". The ultra-connected modernity shares the "instant life" through social media and awaits something meaningful. The lack of meaningful experiences brings an urgency for a consumerism supported by the experiences based mainly on images and poor text, which bring society to an extremely visual-based experience. The traditional rules to control social and moral behaviour no longer work, and people rule their lives by the market, establishing a

standard behaviour (Belk, 2014). Even if they decide to be against hegemony, they just can be a market for this hegemony. A person is what he has, and spiritualizes the things he possesses. This means the objectification of life.

The Cybercutural society also brings a new reality: the absence of perceived, objective truths. New approaches to the world present themselves, we easily can find occultism, the growing return of fundamentalism, the return to the self-conceived as a refuge from society, considered aggressive and incapable of satisfying the aspirations of human beings. The worship of the present, the body, the focus on oneself and fashion channel interests; fragmentation of time in a series of perpetual gifts (Bauman, 2013). There is also weak thinking: it means the apotheosis of light and predominance of imagery over verbal or textual; the absence of an ideology or belief capable of explaining the world. The End of History Era: loss of the emancipatory sense of history and faith in progress or any utopia that proclaims the construction of a more human world.

According to Bauman (2013), the postmodern population is not free, but remains controlled, monitored, determined and instilled by the flows and ebbs of the market. No matter what and whatever, the success of the new is in its approval and consolidation as a new acceptance, that is, the act of consumption itself becomes a way of measuring the plausibility of the novelty.

If we consider schools in the digital age, the Liquid Times can be complicated. While the pedagogies offered by these and other mobile devices work with fun, with the combination of multimedia aspects (such as sound, movement and colour), the activities proposed by teachers are mostly based on exposition, homeworking and, finally, the exams, (Beetham & Sharpe, 2013). Often the activities are based on repetition, and everything at school is similar. The school has always been a place for standardizing human thinking and the production of "equals". The school routine is not made for children in the digital age, who believe in being different. They believe in having a voice, and can give opinion about anything, because the answer is on Google. The search tool is the new Oracle: if it is there, it is true, relevant and reliable just because it is on Internet.

Another point to consider is the school does not work with learners of an immutable knowledge anymore. Teachers must be aware their role has changed: in the digital age, knowledge is not centralized in one person or even a unique device anymore, but can be reached by those who are interested in learning (Oblinger & Lippincott, 2006). Teachers are

partners, mentors, but they have lost the title of "knowledge owners". Still, for traditional schools it is not productive keep the same recipe of dealing with "old regular" groups of children (Siemens, 2014).

2.1.1. The Cybercultural Society

Jarvis (2014), states that in the postmodern age, we find fragmentation, ephemeral, discontinuous and chaotic change in the thinking of society. The social changes also modify space and time concepts, which are defined by those integrating the ideological hegemony. According to the author, the Digital Age brings many controversial implications, such as intensified discussions about copyright and its relevance, and similarly in artistic design and music format, television, cinema with the cuts in time and space scenes, or in human personality. To Lemos (2010), technological development can be considered in three phases: the phase of indifference (in the Medieval Ages), the stage of comfort (Modernity) and the phase of the ubiquity (Postmodernity). Especially in the third phase, also considered the stage of communication and digital information, there appears to be a control of nature and the emergence of digital technologies that enable the non-linearity of time and deterritorialization. Therefore, "the virtual worlds arise, the instantaneous time, the abolition of physical space, in short, all the transcendence of powers and symbolic control of space and time" (Bauman, 2013a).

Bauman is the sociologist who conveys his perception of the world without nostalgia. In his later works he has used the term "liquefaction" or "fluidity" as an adequate metaphor to express the dynamism of the transition process between modernity and the present phase, which Bauman himself prefers to understand as a postmodernity. The presentation of the person as an individual became the main characteristic of modern society, in opposition to the "Fordist model", the modern age symbol. Despite internal conflicts, the previous society was a synonym of security for the individual. Bauman sees the "will for freedom" as the mainstay of liquid modernity, which opposes the "security" built around the stability or, in better words, a static social life in the modern order. Asked several times by the Academy for an exact definition of Liquid Times (2013), Bauman chose to express the idea through his books, simply, that makes his work complex and the concept, broad.

Before Bauman introduce the concept of Liquid modernity, Marx and Engels

characterized the Modernity as the historical process that melted all institutions of other epochs. The family, the traditional community (culturally peculiar and closed to strangers), and religion, the State. The objective of the melting proposed by modernity was to question every point in life, discarding the irrationality and the lack of plausible justification that each object of criticism contained, also maintaining or relocating in the rational and enlightened project the characteristics still usable.

What happens today is a repetition of what happened before at the transition from the pre-modern to the modern world. The "melting" of modern social parameters is the work of the same forces of paradigms deconstruction of the traditional societies prior to modern societies. However, nowadays there is no reconstruction of "solid" parameters. These remain in their fluid form, being able to take the form determined by individual and social forces, at specific moments.

The transition from liquid modernity to the post-industrial society of consumerism, from the production society to the consumer society was a very powerful and important event. The focus has been changed from building the bases of society's power over nature to the opposite: to the culture of immediacy, pleasure, individualization, to identifying the vision of happiness with increasing consumption.

In practical terms, this brings the society into the end of utopias. The net society, contrary to what happened during the twentieth century, does not think in the long run, cannot transform its desires into a long-lasting project and hard and intense work for humanity. The greatest projects of new societies have been lost and the strength of human association is no longer focused on the achievement of a goal.

Utopia was the way of realising that actual reality needed to be changed with the force for its modification (hope in the human potential of transformation). There was the confirmation that the world needed to be changed and enough social interactions to create groups, to engage people and to move nations so that modifications could be made. These two basic conditions for sustaining utopia disappeared as society begun to be deregulated and disorderly.

The end of utopias is the loss of the reflective character regarding to society, consequently, the society do not think about progress as a good that must be shared. The pursuit of individual pleasure is the main objective of web society. Bauman explains that today's society is deregulated because the market is what dictates the rules and rules of the

market are marked by the capitalist economic objective: the annihilation of competitors and success with consumers (Bauman, 2013). Life also became messy, since there is no longer the clear divisions that preceded postmodernity (such as the division of the communist bloc and the capitalist bloc). This reality is experienced on a personal scale, with individual relationships, amplified by the use of social networks.

The educational system is one of the victims of the culture of immediacy. Education and immediacy are contradictory terms. Either you have a quality education or you have the immediacy. Education and quality will not walk together in the information and technology Age, which is a library of fragments, of small bits, without something that brings them together and turns them into wisdom, into knowledge. Population in Digital Age do not have time to transform and recycle fragments of varied information into a vision, into something like wisdom. Wisdom shows us how to proceed. Understanding a complex situation means also understand what is the next step, how to deal with this. It seems the Liquid Modernity is missing this point.

In liquid modernity, "[...] people who will have more power are those elusive, those who are free to move imperceptibly" (Bauman, 2013: 140). The work without body, the liquid loves (made to not last, that undo as soon as the charm is finished), the companies without patrimony (Deliveroo, Uber, Airbnb), the individualization and the perpetuation of the solitude, although we are the society more connected than ever before.

Cyberculture is the expression coined by the philosopher Pierre Lévy to define the digital world and its multiple facets. According to Lévy (1999)'s definition, Cyberculture is introduced as the wish for being socially connected, which flows from affinities and interests in a virtual space that is in constant motion. Cyberculture specifies the "set of techniques (material and intellectual), practices, attitudes, modes of thought and values that develop ~~as~~ at the same time as cyberspace growth "(Lévy, 2000, p. 17).

Another aspect highlighted in cyberculture is the impact of individual decisions within the issues produced socially, which means, success or failure in professional life. "... Employment, as well as social position and the concrete conditions of existence, is seen as the result of personal engagement, disconnected from general economic conditions and political "(Levy, p. 99).

Cyberculture, in general, is the new historical moment when every relationship is established through information and the ability of processing and generating knowledge

through the web. This phenomenon is called by Castells (1999) "Network society", whose revolutionary method consists in the Internet appropriating uses and features incorporated by Capitalism. The network society is also analysed by Levy (1999) under the code name "Cyberspace", and therefore this new interaction space is afforded by virtual reality[1] (created from a mobile literacy). While explaining the virtuality, the cybernetics culture in which people experience a new relationship between space and time, Lévy (1998) uses the same analogy of the "network" to indicate the formation of a "collective intelligence".

The possibility of participation or elimination from the digital universe, being part of the data processing and knowledge production or even standing on the sidelines of this dynamic affects all the human relationships in which communication is active, defining the anthropological aspects, social and even philosophical. From the economic perspective, the network has brought profound changes to society, redefining the International Division of Labour (DIT) across countries and economies.

To Lemos (2002), Cyberculture is not a future that will come, as it is possible already to observe cybercultural's effects on human lives. For this author cyberculture is the Contemporary culture defined by digital technologies, and there is a deep relationship among developments in technology and modern culture. It also means a sociocultural form emerging from the symbiotic relationship between society, culture and new microelectronics technologies that seeks to maintain a complex relationship with the contents of social life through the emergence of new relations influenced by digital technologies.

In the digital society it is possible to observe people connected in every way, and there is the need to expand pedagogical concepts and formulate a model in which students can be active participants and producers of their knowledge, not just mere recipients of content, with a participatory learning, social process. Lévy (1999) says the cyber connection, in Cyberculture, is always preferable to Isolation: it is a "good" in itself. Interconnection is considered one of the stronger elements in cyberspace origin. Thus, cyber civilization shows the signs of a generalized telepresence. In addition to a physical communication, interconnection constitutes humanity in a continuous borderless whole and "information media would no longer be in space, but like a topological twist, the entire space would

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[1] Pierre Lévy, in his book "Becoming Virtual: Reality in the Digital Age", discusses the reality formed from virtual spaces. Levy tackles the concept of "the virtual," clearly defining it alongside "the real," "the actual," and "the possible."

become an interactive channel "(Lévy, 1999, p.127).

Lévy (1999) talks about collective intelligence that arises inside the debate about intelligence technologies: it would be a sustainable way of thinking within the social connections that use open networks of Internet computing. Thus, "Collective intelligence is a distributed intelligence to everywhere, increasingly valued, coordinated in real time, resulting in the effective mobilization of skills and whose objective is the recognition and mutual enrichment of people and not the privilege to fetishized or hypostatized communities (LÉVY, p. 28-29, 1998).

Collective intelligence makes use of cyberspace and intellectual technologies as a set of several features that use consciousness or not, to expand the possibilities of our communication, enhance the development of our thought, and produce new knowledge (Levy,1998). Thus, collective intelligence takes place when society finds a balanced way of living, according to Lévy (2000).

Cyberculture has transformed social relations, once the social environment constitutes from relationship with society, culture and new technologies in micro-electronic basis. Cyberculture shows new determinism in contemporary culture characterized by technology intellectuals. New communication consists of the reconfiguration of practices, modalities, spaces without replacing their background, e.g.: newspapers, magazines, radio. In Cyberculture, these media have not ceased to exist, they are just transformed and reconfigured, but their essence remains the same. It means the communication process of cyberculture includes migration to other media and not the extinction of previous ones.

In Cyberculture, we begin to live with new social relations. It does not necessarily mean the extinction of direct contact between men, but this will be expanded to the contact between men and machines, and machines that start to change information autonomously and independently.

The education proposed for the twenty-first century should be focused on incorporating the current innovations from a social context, based on critical and autonomous training, thereby ensuring that teachers and students are partners in the construction of knowledge. The amount of information exchanged through diverse information channels, including the Internet, and the full access to these means, is opposite from the behaviourist and decontextualized educational practice. It is necessary for students to understand what they do, developing the skills to extract from various sources information the main relevant

idea, bringing applicability to experiencing in their classrooms and lives (Almeida, 2011).

2.1.2 The relationship with knowledge in cyberculture

Within scientific and technological developments, the information becomes transient and temporal (Levy, 1998). According to Lévy (1998), designing tomorrow's education in cyberspace requires the permanent analysis of knowledge, because society is facing a redistribution of knowledge configuration that links the new technical configuration to the new relationship with the cosmos. The knowledge construction in cyberspace demands new educational habits that encourage individual and collaborative learning as the individual is just one of the "micro actors "of a cognitive ecology. The "thinking occurs in a network in which neurons, cognitive modules, human, educational institutions, languages, writing systems, books and computers are interconnected, transformed and brings new representations " (Lévy, 1993, p. 135).

Learning while accessing Cyberspace is processed by students and by teachers as well "... to continuously update their knowledge as their teaching skills "(Lévy, 1999, p. 171). For this author, the idea of teachers being Knowledge transmitters becomes meaningless, since cyberspace has more effective ways to do it. It is also important to recognize that in Constructivist approach, nobody can "transfer knowledge": is just possible help the learner to follow the steps more easily. Lévy advocates the multiple and varied sources on cyberspace and web search tools can give the student more effective feedback within a shorter time, which is not possible for teachers. Among other things, the idea of knowledge in contemporary times, reports to network thinking. Thus, the teacher's work seems meaningful only when he develops a teaching job that mirrors the network's construction of thinking. This professional, according to Levy, is designed as the "stimulator of the collective intelligence" of the students and should encourage the process of learning and knowledge building.

The relationship between humans and knowledge begins with the desire for obtaining pleasure, enjoyment, sense, not very much by the object itself (Charlot, 2016, p. 37). In other words, knowledge is the result of subject's intellectual construction, that is, it implies a conception of individuals, whether as unfinished, social, natural and historical or as a passive being, mere receiver. For the author, possibly, Humanity is beginning to enter into an

informational society and moving out of a knowledge society[2].

According to this perspective, the school has a central function, the construction of knowledge and cognitive and intellectual skills. Part of the understanding that education is a threefold process of humanization, socialization and individualization, which is done through access and appropriation of human heritage. Therefore educators in general advocates an active pedagogy that aims at quality, which can discern access to school from access to knowledge, because "... a low-risk-pedagogy is a pedagogy without training, while people learn nothing "(Charlot, 2016, p. 69). This pedagogy needs to develop challenging activities that require reflection from students and further elaboration of thought.

It is necessary that the learning situation can be meaningful for the student, so that motivates them to attend school, especially in looking for study (Charlot, 2016). The author says that in education, the question of meaning, of intellectual activity and pleasure in relation to knowledge needs to be considered.

It seems that the teacher needed for the twenty-first century needs to work with students to develop their ability to organize the network thinking, filter information deemed relevant and transform it into knowledge with a critical eye (Oblinger, 2005). Working with the various possibilities of access to information and building knowledge, making a pleasant and motivating activity. To this end, it also seems relevant in a further opportunity to students exploring the cyberspace universe, guiding them, especially in the awareness that it is not a neutral environment, devoid of ideologies and that can have an effect on our subjectivity and behaviour. The interaction through social networks, the internet in general and collaborative learning has been widely explored in academic research. Students prefer to use their own devices to support their learning and also make use of messengers, like Messenger, Facebook and Whatsapp to support their learning (Oblinger, 2014). These tools have several functions, among them are to enable students to collaborate, communicate to share resources and information related to the course. They also rely on daily social and leisure activities, and also use up the network for leisure.

According to Sefton-Green (2012), young people who use digital technologies with

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[2] For this work, we adopt a Constructivist perception of Information (Information is processed data) and Knowledge (when information that is modeled to be useful for everyday life). To get knowledge people will need some cognitive and analytical abilities, while to get information the person just need to be a receptor without mobilizing any cognitive ability.

their social peers also develop a number of other skills such as those involving speeches and construction of meaning, identity and exploitation and control claim. Sefton-Green also says that young people have become used to negotiating roles in social networking and exchanging of identities easily. It's easy, for example, for a young person perform the role of teacher in a community of learning and then just as easily switch sides, turn out to be student and apprentice.

2.1.3. Digital Technologies and Schools

A great challenge for teachers might be to encourage critical thinking and bring a positive impact on reflective action by the students, while dealing with the social movement over technologies, the way technological devices have been incorporated by society, it is possible to observe that the appropriated motivation to the use of digital technologies devices in school. In the last two decades, the discussion about technology and school reform has taken shape. The computerized workplace and the use of telecommunications in the daily routine of society are sufficient arguments for those who defend the modernization of schools so that students might operate in a familiar environment, dealing with the digital technological devices.

One of the main issues of our society is the rapid changes occurring in the economic field. This process impinges on various spheres of everyday life, changing the way we interact, work and learn. So, Valente argues that:

> These changes imply profound changes in virtually all segments of our society, affecting the way we act and think. They demarcate the transition to the knowledge society. […] This appreciation of knowledge demands a new approach of professionals in general and therefore requires the rethinking of educational processes, especially those that are directly related to the professional training and learning processes. (Valente, 1993).

Among some requirements for the professional twenty-first century, the most important ability is being flexible, which implies the development of creative potential and also the ability to incorporate the constant innovations arising within the production process. While in the industrial society it was up to the worker to perform repeated tasks and timed, in the informational environment, it is possible that at any moment this same professional

acts in different parts of the production, being more autonomous in managing their actions.

The technical and scientific development, meanwhile, propelling new discoveries, generates major changes in human life and work, featuring this time period as the Third Industrial Revolution and technological revolution (Meszaros, 2015). The demand for an ever greater mastery of knowledge and skills to deal with this diverse and complex reality, imposes new concepts of teaching, school and education.

The school, as a social institution, is called to meet satisfactorily the demands of modernity. Innovations of technology are very important, and it is imperative the school's organizers understand the knowledge relating to them in order to pass them on to their customers; therefore it is necessary that the school fosters such knowledge and skills necessary to teach aiming the full exercise of children's citizenship.

Apparently, many educational institutions still retain a referenced structure in mass formation, in which managers seek to implement measures with strong hierarchical rigidity, which is also reproduced in the idea that teachers have all the knowledge, leaving students to play the role which their masters deem important to learn. In this aspect, the changes taking place in education ~~is~~ are slow, almost imperceptible. Schools which claim to be "constructivist" or "cognitive" are still working on the behaviourist perspective. Thus, the question that arises is "How will the changes that are happening in society affect education and what will be its pedagogical implications? " The pedagogical change that all desire is the passage of an Education is based entirely on transmitting information in instruction, for creating learning environments in which student performs activities and builds knowledge.

The thought that humanity is moving inside a multidimensional realm (rationality, politics, education) with paradigmatic transition, has opened the debate about the emerging cybercultural paradigm, also called by Castells (2015) as "information society". The understanding of the paradigm can be conceived as the part of a relational approach, "... in which sovereign concepts and theories live together with rival theories " (Moraes, 2007, p. 32). For this reason, the contemporary condition, also called Post-modern, adds historical remnants of previous periods; part of their desires, especially linked to the educational field, come from other historical eras, however, and gain prominence with the advent of ICTs.

According to Cazeloto (2008), in the historical period we live,

There is not a founder or reporting timeframes defined and consensually accepted (as modernity or the Middle Ages) to mark its entry into history of imaginary boundaries between seasons. There is no "postmodern manifesto" to mark a point break in history (p. 21).

It clearly seems that Humanity has easily changed from the analogic paradigm to digital society, without an apparent revolution. The cybercultural society expresses different ways to learn, teach, and systematize new forms of research. This implies that formal knowledge must optimize the ability to respond consciously and fast to unexpected challenges that take place in everyday life. As Tavares states, "... both in organizations and in people, new ways to be, to act, to power, to communicate, to relate and to be with others will have to correspond to new forms of knowledge, information and communication " (2016, p. 12).

The cultural production and socio-technical phenomena that emerged from relationship between humans and mobile technologies while connected to the World Wide Web, can characterize and shape the contemporary culture as Cyberculture. This notion has been increasingly discussed as the cyberspace culture and overlapped physical space. Cyberspace is the Internet inhabited by humans to produce content and social networks mediated by digital technologies. The Citizen from third millennium needs the ability to analyze and judge information available more than ever, due to the abundance and variety of information. The same skills are found in a critical thinker.

2.1.4. The Constructivist approach: theoretical framework

Is important present some relevant information about Constructivism, once this study has a similar conception of teaching and learning. Constructivists understand learning as an active process of building, not acquiring or "absorbing" knowledge. The most important issue on Constructivism is to develop abilities to understand the "why" of things, not just repeat a mechanical action. The purpose of the instructional process is to help this construction, not transmit knowledge, because this will come if the right skills has been developed. The learner holds the main role: a knowledge builder, becoming the centre of educational process for teachers, content, media and environment. All these elements only make sense if they contribute to bring conditions for the learner knowledge building.

The epistemological perspective of interactionism, represented by the thought of Piaget, is a synthesis of empiricism and rationalism. The author disagrees with the ideas that knowledge is born with the individual or is given by the social environment. He states the subject builds knowledge in interaction with the physical and social environment, and this construction will depend on both the individual conditions as the environmental conditions (Darsie, 2015).

The main idea of Piaget's theory is that knowledge does not proceed only from the unique experience of objects, or the wide innate genetic conditions, performed on the subject. It comes from successive constructions with constant elaboration of new structures, which are resulting from the relationship between object x subject, where one of the terms are not in opposition to the other, forming a complete system. Thus, Piaget's conception of learning disagrees with the ideas discussed above and has been thoroughly expressed in all his work. Although he denies that his work constitutes a theory of learning, naming it as a theory of development, he admits his ideas can be used for the comprehension of the learning and teaching process. (Giusta, 2013).

According to Becker (2008), pedagogy derived from this interactionist epistemology (Relational Pedagogy, according to the author) the teacher thinks the students can just learn something or will build some new knowledge, if he acts and discuss their action, under a certain level of criticism and reflection. Learning is to build: to act and be aware of the consequences of actions. Thus, it is not possible overstate the importance of hereditary components or the importance of the social environment.

Therefore, the interactionist theory brings a solution to the dichotomy of transmission *versus* production of knowledge, allowing us to bring back the unity of knowledge, through the vision of the subject and object, where the objectivity of world and subjectivity, considered as an individual moment of objectivity's internalization, as the basis for any investigation. It Is possible to come to the conclusion that the pedagogical practices that are based on the interactional conception of learning must rely on two fundamental truths: that all knowledge comes from social practice and that knowledge is a collective venture and cannot be produced in the solitude of the subject, if only because that loneliness is impossible (Giusta, 2013).

Vygotsky, according to Freitas (2000), conceives of man as a historical product and a set of social relations. He wonders how social factors can shape the mind and build the psyche

and the answer stems from a semiotic perspective, in which the sign, as a social product, has a generating function and organizer of the psychological processes. The author believes that consciousness is engendered in the social, from the relations that men establish among themselves, through a semiotic activity, therefore, through the mediation of language. The signs are the instruments that internally acting in man, causing him internal transformations, which do move from being biological to socio-historical.

There are no internal signs, in conscience, that have not been engendered in semiotic ideological fabric of society. The analysis performed to cognitive theories presented, allows us to note that, even not noticeable, some behavioral trends of teaching and learning hold out on current days. The Skinner's operant conditioning proliferated on education in the thirties and extended to systems of programmed instruction. At school level, such theoretical approaches are used to support a transmissive pedagogy, based and the reinforcement in order to obtain desirable behaviors (Cachapuz et al., 1999). The classic example is the school that wants to teach his students to deposit the trash in the right place: the trash can. The school can use Behaviorist methods, rewarding the student who recycles their rubbish and punishing the student who does the opposite (stimulus-response). In a constructivist approach, it would be different: talking, debating, proposing actions within the school. Allowing students know all the implications of not putting garbage in the proper place and the consequences of it. The student of a Constructivist method will go into adulthood knowing that it is his duty to build a better life. What will happen to the student of Behaviouristic approach when he sees himself without "reward" to the act of doing what is right?

Aiming to develop an approach in psychology within the materialistic point of view, Vygotsky and his collaborators worked to recover the study of consciousness, bringing Pavlov's contributions (who was an empiricist) in a broader perspective investigations and in contrast with the prevailing ideas in the period of their studies (Rego , 2002). Vygotsky (1995) states that the social environment is a determinant of human development and that this happens mainly due to the learning of language which occurs through imitation.

Vygotsky, according to Freitas (2000), sees the man as a historical product and a set of social relations. He talks about the impact of social factors on mind and psyche, bringing a semiotic perspective. For him, the "sign", as a social product, has a generating function and helps to organize the psychological processes. The author believes that consciousness is engendered socially, from the relations that men establish among themselves, through a

semiotic activity, therefore, through the mediation of language. The signs are the instruments that internally acting in man, causing him internal transformations, which do move from being biological to socio-historical. Thus, from the point of view of learning, the importance of Vygotsky's studies is unquestionable because he criticizes theories that separate learning from development (Giusta, 2013).

Siemens (2014) brings the concept of Connectivism to note that none of the theories - behaviorism, cognitivism and constructivism - meet the new conditions of learning and the new ecology involving plenty of information, people, software, and particularly, nets and connectivity. According to Siemens, is not the individual's change of state that promotes learning; is not even the experience that brings it. The system of self-organization that involves the individual that begins the learning process within human beings and expands out of the singular body. How this happens is announced, but it is unclear.

2.2 Critical Thinking: why this is important

Critical thinking may be understood as "the ability to evaluate and judge evidence, arguments and situations regardless of someone`s own beliefs and opinions" (Esterle, 1993). More recently, this discussion has been presented (Almeida, 2011) in relation to how information analysis skills can be directly linked to critical thinking. Within this context, there is a need to reassess the concepts concerning critical thinking so that they are relevant to the digital generation. In order to fully exploit these increasingly rich digital environments, critical learning spaces within schools must be given priority in the digital generation.

Being critical, especially in the digital age, may be linked to being a researcher of information: wherein a student is led to look for reasons and evidence of a particular argument. This begins when we exercise mastery over certain thinking skills such as learning to perceive forms of invalid argument, defend distinctions, and look for invalid or false sources of information.

For Donovan et al (2004), the "critical spirit" is a deep character trait, in the exercise of critical provisions. Such a critical spirit makes the difference between "weak skills" and "strong skills" in critical thinking, so that "weak skills" means that the subject may be able to put critical thinking skills into practice when required. Whereas "strong skills" point to a

subject that incorporates these skills as an integral way of life, where assumptions are re-examined and questioned as well. According to Bransford et al. (2004), a "strong" critical thinker looks for "clarity, accuracy, and is also free of prejudices."

2.2.1. Criticism

Before talking about criticism and critical thinking, it is necessary to address the aspects inherent in voluntary activity itself. At first, it is known that in most conceptions of teaching and learning, student autonomy is relegated to the background, since most actions are made and idealized with the teacher as the main actor of the process. However, the healthy development of the student in the school is related to the construction of his autonomous, sociable identity, whose achievements and objectives are directed to the community, in the exercise of his citizen awareness: the moment when the person is aware of his rights and duties and can exercise his citizenship aiming a better society (Freire, 2000).

School research emerges as an exercise in critical citizen awareness, and the exercise that is done by critically analysing information is really important for developing critical thinking. Education should be seen as a powerful weapon in the "formation of historical human competence" (Demo, 2011, p. 175), conceiving subjects active in its history and that of its own society, but emancipatory education must not leave aside the goal that your students demonstrate their knowledge, reworking it. Under these circumstances, the first step towards a pedagogy of the Autonomy of the human being is done when his thoughts, beliefs and world conceptions have been pushed up under the Enlightenment's light, as said:

> *Enlightenment is mankind's exit from its self-incurred immaturity. Immaturity* is the inability to make use of one's own understanding without the guidance of another. *Self-incurred* is this inability if its cause lies not in the lack of understanding but rather in the lack of the resolution and the courage to use it without the guidance of another. *Sapere aude!* Have the courage to use your *own* understanding is thus the motto of enlightenment. (Kant, cited by Foucault, 1997)

To understand Kant's statement is to think the Enlightenment's concept comes with a two-sided relation of compatible but distinct contexts. Firstly, we have the subjective perspective that refers to the person himself, and secondly, the objective perspective, which refers to a qualification attributed to a historical time. The text can be said to address both the meaning of Enlightenment and the "spirit" of Enlightenment. However, both contexts are

not isolated, their point of contact is the concept of "Public Use of Reason", which founds a transitional framework between private space and public space or between the individual scope and the community scope. It is difficult to find commentaries on this text that sufficiently accentuate this difference and the balance that those two areas need to maintain among themselves. Is necessary to think about Enlightenment with a broader and holistic vision: Enlightenment can be the critic, itself, the light that comes to one self with the exercise of reasoning.

The first requirement to define the meaning of enlightenment is the willingness to make use of one's understanding. In this rather synthetic characterization, at least two questions arise: what does it mean to use one's own understanding? What is meant by understanding, that is, is it merely a theoretical use or is it also a practical use of reason? How is Kant's claim related to the demands of the Digital Age?

It does not help much to affirm that clarification is to think for oneself. In the same text named "What is Enlightenment" (cited above) it is possible to find a part of the text that helps to enlighten it. Kant writes that "Precepts and formulas, those mechanical instruments of a rational use, or rather misuse, of his natural endowments, are the ball and chain of an everlasting minority. And anyone who did throw them off would still make only an uncertain leap over even the narrowest ditch, since he would not be accustomed to free movement of this kind." (Foucault, 1997, p. 30). The most important point of Kant's statement is there is no formula to think critically, or, there is only one formula: staying free from formulas and mechanical instruments. Every movement which considers bringing a unique formula to fulfil every human being's necessity must hold the person exactly at the same place. Being "normal" means "following the pattern", thinking and acting like everybody. It works like chains. Once free, the person will try to move alone, away from those models, but the uncertainty will follow his steps.

It is now possible to distinguish between enlightenment and criticism: Enlightenment is the clarification as an attempt to avoid excessive government by others, whereas criticism would be the modern attitude of asking for its own actuality and the critical enterprise as founding an analyser of truth.

Not only for Kantian philosophy, but for the whole of modern society, post French Revolution (1789), the autonomy of the subject is a very important principle. This is because the subject, making good use of his rationality, can overcome the minority view and construct

the scientific knowledge, without influence of beliefs or prejudices, in order to dominate and quantify all the reality.

Using reason or understanding means the person needs to mobilize skills in order to think and reflect only according to the rules that human reason itself offers. Kant states explicitly that "freedom of thought means that reason submits itself to no law other than that which gives itself. The opposite is the maxim of a lawless use of reason (in this way, as genius dreams, see further than keeping itself attached to laws)".

Enlightenment, however, is the main intention of the sciences, once the use of the reason may enable the human's emancipatory process, it also should be one of the main interests and objectives of Education and Training. Therefore, the interest of educational knowledge for emergent critical formation also goes through Enlightenment. Enlightenment is important in a society that, although not developed as the societies of the developed countries, has the means to be informed of everything, and can know most of relevant findings that happens in the world. It is believed that society and men have never been so enlightened. There are "enlightenments" of the most varied forms and with the most varied interests, from the window to the world like the television and the internet.

Science itself seems to have reached the apogee of the "disenchantment of the World" overcoming any and all obscurantism, such as the fear of natural phenomena or the wrath of gods, or of guilt and destiny. Thus, one could generate a huge list of themes that were once taboo, and today are evidence of everyday life, themes that for so long were practically untouchable. Apart of all these more complex scientific issues and the progress of science and technology, as well as clarification itself, this "enlightenment" does not free mankind from conservative judgements and does not decrease the barbarity in the world.

There are other relevant aspects to consider, while talking about critical judgement and enlightenment. Human Nature has its own instincts. However, we are not meant to be misogynist, racist or homophobic. We learn there are options available. These options are presented by society, where they will develop, which brings us to the *Habitus*.

2.2.2. The Habitus

The socialization process of modern societies can be considered a plural space of multiple social relations. It can be considered a field structured by the dynamic relations between institutions and social agents distinctly positioned depending on their visibility and available resources. Emphasizing the relationship and interdependence between the instances and agents of socialization is one way of stating that the relations established among them may make them be allied or opponents. They may be relations of continuity or rupture. They can, therefore, determine a varied and heterogeneous range of unique experiences of socialization.

Based on research carried out in Algeria and among peasants in the French region of Béarn (Bourdieu, 1963, 1972), the concept of habitus arises from the empirical necessity of apprehending relationships between the behaviour of agents and conditioning social structures. However, in order to understand critical thinking in the digital age we will need to understand *Habitus* in a broader concept, as Bourdieu could propose in 1990:

> [Habitus are] Systems of durable, transposable dispositions, structured structures predisposed to function as structuring structures, that is, as principles which generate and organize practices and representations that can be objectively adapted to their outcomes without presupposing a conscious aiming at ends or an express mastery of the operations necessary in order to attain them. Objectively "regulated" and "regular" without being in any way the product of obedience to rules, they can be collectively orchestrated without being the product of the organizing action of a conductor. (1985:p. 53)

The Habitus, as observed, is something complex and transcends the merely superficial formation of humans. Habitus can define the success or failure of an intellective citizen-awareness investment, depending on how strong its structure is. Habitus can be understood as the whole life story and complex social forces that have acted upon the Self, even before he/she became so. The Habitus is understood as the structures incorporated by the agents of a given field, a knowledge acquired and naturalized in the social practice of a microcosm. It covers beyond the individual and the author intends to overcome the preponderance of subjectivism and/or objectivism in the social and human sciences.

Power, according to Bourdieu (1985) is located on a two-way street between agents and structures, which suggests subjectivities and objectivities, and generates new

relationships constantly. The theory seeks to understand, precisely, the interface between these two elements that are at the root of sociological discussion since the beginning of scientific studies. In balancing the weight of importance between structure and agent, Pierre Bourdieu seeks to explain why, in everyday life, normal people act reasonably appropriately to the situations in which they find themselves, regardless of the crazy ideas they often demonstrate about such situations: their practical sense does not pay attention to speech (Callewaert, 2003). In this way, the author respects the different and also antagonistic logics of agent and structure, discourse and action, moving away from the idea that social action is reduced to meaning.

Bourdieu established the practice of power to two variants: symbolic capital and habitus, both located within the social fields. Pierre Bourdieu, especially when discussing the concept of symbolic power discusses the notion of social field. The author gives the social field the sense of space of dispute and mastery of experience by a sociological bias. In "On Television", Pierre Bourdieu conceptualizes the social field as:

> a structured social space, a field of forces - there are dominant and dominated, there are constant, permanent relations of inequality that are exercised inside this space - which is also a field of struggles to transform or conserve this field of forces (Bourdieu, 1997, p.57)

Pierre Bourdieu named this kind of thought as structuralist-constructivist and brought the idea of the formation of social fields, with the notion of habitus and symbolic capital. In his researches, trying to define how the power registered in social fields and in their relations manifests itself, the author underpins the commitment to reveal the implicit forms of class domination in capitalist societies, defending the thesis that the ruling class does not dominate completely and does not force their dominated to conform to domination. Here, it is possible to observe Bourdieu apparently tracing in the same route as Karl Marx, but what he says is exactly the opposite: The Habitus, in opposition to Marx's definitions, can bring some limitations to the individual, but cannot make him stop his journey.

Bourdieu was a strong critic of methodological monotheism, suggesting a combination of "[...] the most classic statistical analysis with a set of in-depth interviews or ethnographic observations [...]. In short, research is something too serious and too difficult to be able to

take the liberty of confusing rigidity, which is the opposite of intelligence and invention, with rigor "(Bourdieu, 1989, p. 55).

In addition, Bourdieu presents power as a symbolic power of construction of reality (Bourdieu, 1989). Rosa (2007) says the manipulation of symbolic aspects in the organization, besides contributing to the formation of a community of signifiers, also plays a role of control. The symbols would then be instruments of social integration, which make possible the consensus about the meaning of the social world. (Bourdieu, 1989). In this perspective, Bourdieu goes further and questions the dominant mode of thinking about power:

> [...] some will wonder where he is, who holds him (Who governs?), others whether he comes from above or below, etc. Is necessary to break with this way of thinking, and because of it I will use the term *field of power*, understanding as such the relations of forces between social positions that guarantee their occupants a sufficient *quantum* of social force - or of capital - so that they have the possibility of entering into the struggles for the monopoly of power, among which a capital dimension has the purpose of defining the legitimate form of power ... (Bourdieu, 1989, p. 28-29, italics in the original).

Thus, power is not something that can be possessed, but a result of relations between social positions, working for the capital; it is an invisible power, which can only be exercised with the complicity of those who do not want to know that they are subject to it or even who controls it. This is an almost magical power that allows us to gain the equivalent of what is obtained by physical or economic force, and, if it is recognized, needs to be ignored as arbitrary (Bourdieu, 1989).

The position of an agent in the social space is defined by the position he/she occupies in different fields. In the distribution of powers that act in each of them, as economic, cultural, social or symbolic capital. In this way, the social field is a multidimensional space of positions, according to the global volume of capital they possess (Bourdieu, 1989).

Applying Bourdieu's definitions to the networks and complexity, it is possible observe some importance given to the position the object occupies in the networks as determinants also of the present dynamics of power or of governance. Analysing the networks of knowledge and their relationship with power, there is a transposition of the field theory of Bourdieu, directed to the individuals, for an analysis of positions based on the networks.

2.2.3. The Power, when it holds criticism

Foucault (2000) says power is nothing more than what results in the forms of the relationship between individuals socially organized, but emphasizing that these subjects are not alien to the process and are not always submissive to it. Foucault sought to unravel the effects that these relations of power bring to society, after all, power for him is configured as a set of social practices and discourses built historically to discipline the body and mind of individuals and social groups. Although is possible to find in literature several other authors that have focused on explaining power and its consequences and influences, some theories are highlighted in this way of conceiving the problem of analysis.

The human being, his relationships and his knowledge were the first objectives in Foucault's research, in order to understand society itself, its way of functioning and structuring (Foucault, 2014). To delimitate what these relations mean, however, it is necessary to understand how power is shaped, mainly by the fact that the author believes that, unlike what comes to mind when talking about power, power relations are not something permanently negative. The power, in Foucaultian conceptions, is not something that presents itself unitary and global, that we can see and demarcate, but something disparate, heterogeneous, constantly hanging, necessarily coming from a social practice historically constituted. As for Bourdieu, power to Foucault is a reflection of exchange and action; however, while Bourdieu deals with power much more through politics and economics, Foucault expands the study of relations, but deals with the effects of power in every human being, whether in politics, economics or social life (Taylor, 2014).

Thus, it is possible to perceive the relation between Habitus and Power: Power, like everything that permeates social relations, presents itself in the social Habitus and works as a bridge to knowledge. Still, the Habitus is capable of stopping knowledge and, at least suppressing it, because in the case of Bourdieu's Habitus it would not be possible to completely stop the questioning process. It would be possible to restrict it, not stop it.

In the critical history of truth there is no subject and object as universal and necessary units; they become subject and object through different practices, which may be theoretical and scientific games, social practices or self-practices. The distance between the subject and the given empirical object makes the politics of truth proposed by the philosopher the mode

of application of a "critical history of Thought" (Foucault, 1997, p.63). The Thought, defined by Foucault, is the place in which rare historical practices are developed, never repeatable, between which are constituted or modified relations between subjects and objects. An object or a subject is this or that, depending on the historical relationship that determines it. This is not about a history of objects, once it main focus is not: neither the representation of a "preexisting object" nor the creation, by speech of an "object that does not exist" (Foucault, 1997, P.67). Also, it does not aim to build the "philosophy of the subject", since it seeks to overcome an analysis that prioritize a transcendent "self" principle or a subject without history.

2.2.4. The critical project

There is a tendency that addresses the critique of truth from the philosophical definition of criticism resulting from the analytical process of the Critique of Pure Reason. However, this second way of thinking criticism is not far from what Kant understood by Enlightenment. In 1784 he defined it in opposition to the state of minority to which mankind had been held by force until then. There was, then, the inability to use one's own understanding without the guidance of other people. Incapacity due to the excess of authority combined with lack of decision and courage. The process of Enlightenment is just the opposite of too much authority and lack of courage. The Kantian "Sapere aude" is inseparable from the critical project.

Foucault points out that Kant establishes an inseparable link between criticism and Enlightenment: "Critique is the foundation of reason made greater in Enlightenment; and conversely, Enlightenment, is the maturity of Critique "(Foucault, 1997, p.567). Without Enlightenment the Criticism would have no reason to exist; without the Critique, Enlightenment would be lost. It turns out that the epistemic character of Criticism necessarily leads to the ethical and political autonomy proposed by Enlightenment; it is worth mentioning, however, that such autonomy would be vague and inconsequential without a fair idea of its limits. For Foucault, the link between Criticism and Enlightenment established by Kant was dismembered in the nineteenth and twentieth centuries. Criticism reduced itself to the epistemic aspect, retreating in the ethic and political fields, as Kant established.

Foucault warns against the developments of a unilateral appreciation of the knowledge critique building up modern science. Knowledge became self-referring, the owner of oneself who led the history of the nineteenth and twentieth centuries to contradictory and disastrous situations. This is the nature of a predominantly positivist science constructed from self-confidence in the critique of its own results: science itself would be valid and applicable to any population at any time, not considering ethnographic variations. In addition, the development systems that presented as rationality of history, but which choose as instruments the procedures of rationalization of the economy and society.

Foucault's way out is simple: to deal with specific, regional, multiple rationalities, as indicated in the different data studied. It means directing the perspectives of Enlightenment beyond the historical destiny of knowledge; to return to the question of Enlightenment no longer by its withdrawal from criticism (identification of the courage to know with the limits of legitimate knowledge), even by a new history of philosophy. Enlightenment is reactivated by Foucault to the mode of historical and philosophical practice. It is a matter of asking to what extent the truth statements about one person, elaborated by the human sciences and philosophy, are inseparable from mechanisms of determined power and subjection. His research deals with the integration of specific histories touched by the relations between structures of rationality. They articulate qualified speeches of true and mechanisms of subjection linked to them. Historical and philosophical practice designates the strategy that articulates truth, power and ethical subject.

> I will say that critique is the movement by which the subject gives himself the right to question truth on its effects of power and question power on its discourses of truth. Well, Then!: critique will be the art of voluntary insubordination, that of reflected intractability. Critique would essentially insure the desubjugation of the subject in the context of what we could call, in a word, the politics of truth (Foucault, 2005 , p. 47)

Foucault used to look at the critical attitude as a result of forces at the present moment operating over someone's life. Those forces could be an event that make the person think and bring people overcome their limits. The critical attitude, Foucault writes, is not "a rejection behaviour. One must escape the alternative of being in or out; it is necessary to acknowledge a place on the frontiers "(Foucault, 1994, p.574).

From the last century, the Positivist conception of an objective truth for all humanity was

refuted, on several occasions and in the most distinct conceptions of thought. Whether it was the relativism of post-structuralist thinkers such as Michel Foucault, or the demarcation of the end of modernity advocated by postmodernists such as Jean-François Lyotard, many "post" recent history as the time when scientific truth lost its objective condition. They, endowed with post-positivist outlines, have called into question the idea that there are irrefutable and universal truths that can bring about some kind of absolute knowledge. This was a very radical change within the scientific fields of the last century - though the idea was always to approach slowly or "asymptotically" the truth.

2.2.5 Theories of mind

The Theories of Mind will help us to understand how Critical Thinking can possibly be fostered at a cognitive level, because they consider mental states while brain is building complex abilities.

The term "theory of the mind" has been used to refer to the capacity of the human being to take into account the human mental states, in order to understand and predict behaviour (Dalke, 1995). This ability would give the person the possibility to consider what other people think and do, a necessary skill in almost all social situations (Jou & Sperb, 1999). In the functionalist perspective, for a theory of the mind to be scientific it must be empirical, which means it must approach the mind in terms of empirically observable properties. If this kind of theory could indeed capture the fundamental nature of mind and cognition, then the mind would be no longer an inscrutable mystery, it would be studied as anything else in nature. Functionalism is an empirical theory that has generated a massive research effort that could, accordingly to their scientists, lead to an explanation of the mind. However, the functionalism that dominates current research in the cognitive sciences remains controversial. There are some scientific approaches that insist on the failure of functionalism in attempting to capture the essential elements of the mind. It is contradictory, however, that even those who reject the theory sometimes admit that there is no better empirical theory on the horizon. Even if functionalism were to be eclipsed or changed one day by a new theory, this new theory would probably have benefited from the lessons learned by research programs that bring functionalism to its limits. Functionalism is a theory of the mind that purports to reveal to us the fundamental nature of our mental states. Mental states include

everything from fear of heights to the belief that it is Friday, from the desire to eat a chocolate turtle to the sharp pain in the leg. Fears, beliefs, desires, pains, all of this are mental states.

Mental states include the cognitive processing of what one is aware of, being accompanied by subjective experiences, or some sort of "feelings". But they also include the cognitive processing of what one is not aware of, for example the pathway performed by the visual system by transforming simple two dimensional lines into a third dimensional world. According to functionalism, the essential nature of desires and pains must not be sought in the 'matter' of which they are composed, but in the 'function' which each performs. Is also possible to describe the essential characteristics of our mental states without mentioning the material from which they are made. We just need to describe the input and output of the 'black box', which is our brain. An approach to a particular mental state, such as pain, will be completed when all its 'functional' properties have been identified.

Functionalism has emerged as a theory of mind, from the philosopher Hilary Putnam (1990), using the "computer metaphor". Saying that mental states are functional properties, as Putnam states, is comparing the mind to a computer program. According to "state-machine functionalism," the mind is identical to the brain, and mental states are essentially brain states. But there is an essential difference between the "identity thesis", according to which mental states are states of computer hardware, and functionalism, according to which mental states are states of computer software, and are functional states, rather than physical states. Thus, they can be "multiplied" in a wide range of different physical states and in all types of systems. No concerns about the matter from which the system is made. If something accomplishes the function, then the system will have such a mental state. Many contemporary functionalist scientists and philosophers believe that our mind is like a piece of software running in the brain, the hardware. But this tells us very little. Do we really know what a computer is? Admitting that the brain is a computer, what kind of computer is it? This is another point of debate between scientists and philosophers.

Homuncular functionalism was developed widely by Daniel Dennett and has been championed by William Lycan (Lycan, 1972). It arose in response to the challenges of the Chinese Brain of Ned Block (Chinese nation) and John Searle's Chinese Room (1980), mental experiments presented by traditional forms of functionalism. Many functionalists argued that such a Chinese nation would in fact possess all the qualitative properties and intentional aspects of a mind: it would become a kind of systemic or collective mind with propositional

attitudes and other mental characteristics. Faced with this hypothesis, it was pointed that the systemic mind, which somehow emerged at the highest level, must necessarily come into the individual minds of each individual member of the Chinese nation to support Block's formulation. However, this would seem to pose in serious doubt, if not directly in contradiction, the fundamental idea of the thesis of supervenience: there can be no modification in the mental realm without a minimum modification in the underlying physical substrate. From the mind-supervenient paradox it seemed to have become acceptable to some in functionalist circles that the only way to solve the puzzle would be to postulate the existence of an entire hierarchical series of levels of mind (analogous to the homunculi). These levels would be less sophisticated in terms of functional organization and physical composition in the descent at the level of the physical-mechanical neuron or the group of neurons. The homunculi of each level, from this perspective, have authentic mental properties, but become simpler and smarter the further down they are in the hierarchy.

Up to the present, philosophical reflection on the construction of a science of consciousness has been carried out for the most part by philosophers using techniques, concepts, and references of the analytic tradition, committed to a representationalist model of the mind. Until the mid-1990s there was little recognition of the relevance of phenomenology in the investigation of the mind. This lack of recognition is often explained in terms of hostility or presumed incommensurability between the analytical philosophy of mind and the phenomenological philosophy of mind. Sometimes the analyst clearly rejects the phenomenological perspective because they think that it tends to regard the mind as an inner realm, implying neo-Cartesianism.

Contrary to the reductionist current, which states that some nonconscious processes can produce consciousness, the phenomenological school considers consciousness as a property or aspect that is irreducible to any other property or material aspect. It promotes softer forms of dualism, coming to defend theories of double aspect or psychophysical parallelism. Searle (1980), for example, defends the phenomenological hypothesis that subjective experience is irreducible to computational neurological explanations. His argument of the Chinese Room was transformed by Jackson (1982) and by Chalmers (1996) into blind neuroscientists of the future who know everything scientists know about vision, even if they do not have the experience of it. In this way, there will always be something she will not know, that is, the subjective experience of colour. Thus, they conclude that such an experience is

something distinct from all the descriptive phenomena in the third person and irreducible to them. The phenomenological philosophy of the mind takes subjectivity as a starting point, both in the logical or epistemological, as in the methodological. For Searle, therefore, scientific experiments and hypotheses always refer to subjective or intersubjective experiences. Even the very existence of an external reality is a postulate of subjectivity.

Thus, these theories ultimately lead to panpsychic theories, which postulate elemental degrees of consciousness in lower biological organisms and even in any physical-chemical unit (Griffin, 1997). Another specific problem of the phenomenological theories of the double aspect is to attribute a status to the known unconscious cognitive phenomena. We do not have experience or subjective awareness of them, but we know by their effects that they are produced, because they attached the behaviour to the subjects. This phenomena, such as that of blind vision, so studied and discussed recently, is important for neural cognitive processes that have no correlate experience. Phenomenologists consider the physicalist tendency, in the name of a scientific worldview, a scientism. However, this does not mean that they have any hostility to science or to the idea that the mind must somehow be part of the natural world (though there may be some scepticism or indifference about how and in what form this fact can be explained).

2.2.6 Critical Thinking

It is now accepted and widely recognized by researchers and educators that critical thinking must be an ideal of education and therefore one of the purposes to be attained at various levels of education. In fact, at the educational level, the promotion of critical thinking capacities of the students has established itself as a legitimate purpose in curricula, especially in science.

Therefore, teachers must bring to everyday classes through their practices the approaches established in various documents, in particular, appropriate strategies to promote critical thinking (Sinclair, Kable, Levett-Jones, 2015). However, empirical studies such as those carried out by the authors mentioned above suggest that the teaching practices in general tend not to, at least in a systematic way, foster critical thinking among students. In addition, it seems to be a pragmatic difficulty of the teacher, which arises from the fact of not

having a clear, unambiguous and reasoned answer to questions such as: "What teaching strategies should be used to foster critical thinking?"

The activities involving research protocol strategies have been of the most investigated strategies, in different levels of science education. Teachers even begin to ask questions, many of them based on typologies of questions, such as the FRISCO approach for students to think about. However, the results of these investigations have not yet shown what always happens the case with this strategy. Instead, it has been assumed that the more or less explicit and grounded orientation for the appeal to critical thinking is that it may explain the promotion of these capacities, as evidenced by the recent study by Vieira and Tenreiro-Vieira (2012) in the formation teachers. This need, therefore, makes it clear that the gap between the teaching that is practised in schools and the effective teaching of thought can be overcome or at least attenuated.

In some teaching and learning concepts, the student's autonomy is relegated to the background, as most of the teaching plans are made and conceived with the teacher as the centre of the whole process. However, the student's development in school is related to the construction of their autonomous identity, whose achievements and objectives are also focused on community, exercising their civic consciousness.

The ideal education is far from happening. Education should be seen as a powerful weapon in the "formation of historical human competence" (Demo, 2015, p.175), designing subjects acting in their history and their own society. According to Carvalho,

> The central research ability appears in own development capacity, or personal formulation, which determines more than anything, the relevant subject in formal terms. Argue, support, question properly, propose and offer counter are initiatives that assume a subject capable. This individuality is irreplaceable. (1994 cited Demo, 2015, p. 19).

To develop their knowledge, students will be exercising their criticism and autonomy. Autonomy means the entire process that involves making critical awareness and preparation for the full exercise of citizenship. Initial training in Degree and teaching courses suggests that teachers should help people, in general, to be more active and agents of their own thinking. This thought must become active, changing the world in which the mind-emancipated student lives, and teachers should help students to see the world more realistically, thereby increasing individual freedoms and expanding the zone of action of human possibilities. If we focus on realities, then the differences increase in size. Being critical

means basically being more efficient in recognizing trait arguments, hasty generalizations without evidence statements, ambiguous or obscure concepts, and so on. Most people need to exercise their critical abilities and question the logic of arguments of most daily activities, "Art to explain, analyse and evaluate these arguments and logic is essential to develop critical literacy skills" (Facione, 2000, p. 64).

The formal and informal logic skills are at the heart of qualities needed to exercise critical thinking, as well as conceptual and epistemological analysis. The main objective in developing critical thinking is to override superficial or distorted thinking, bringing to the surface the thought based on research and analysis processes. For the tradition of critical reflection, as Facione says, critical thinking aimed at self-sufficiency, and "a self-sufficient person is a liberated person, free from unwarranted and undesirable control" (Facione, p.65).

Some statements, although they are true, will carry within them a partisan ideology. In a liberal pedagogy, these issues cannot come dissociated from the overall analysis, there is no way to separate social questions from a reasonable critique of the current policy. In education, concerns about critical thinking are historical.

This concern, appropriate for our time, is where the subject must be the author of his own story. When talking about critical thinking, it is imperative to emphasize that specific reasoning skills should permeate the teaching curriculum in total, knowing that the purpose of general education is to foster this kind of thinking, and develop the skills needed to think criticality. It is possible to infuse teaching and learning at all educational levels. Critical thinking is directly linked to the notion of rationality.

Being critical, especially in the digital age, means to be a researcher of information, looking for reasons and evidence of a particular argument. This begins when exercising domination over certain thinking skills: to perceive forms of invalid argument, expertise and defend distinctions. Some authors (Paul & Elder, 2006; Facione, 2000) have recognized that the traditional curriculum content and their "skills" are of little importance if students do not develop the provisions or inclination to look at the world through a critical lens. So when it comes to critical thinking it is said that the critical subject has not only the skills to think with criticism, but he knows the need to validate the arguments submitted by scientific quest, and have that provision. For example, Facione states that a critical person needs to have to look, analyse arguments, and stay well informed, but he also needs to present a predisposition to do these things (ibid).

For Bransford (2004), the critical provisions (the "critical spirit") is a character trait, deep, that is in the exercise of critical provisions. It also makes a difference between the skills and dispositions, the "weak skills" and "strong skills" on critical thinking. The "weak skills" means that the subject has demonstrated skills and may be able to put them into practice when requested, while the "strong skills" show a subject that incorporated those skills to his way of life, where assumptions are re-examined and questioned as well. According to the author, a "strong" critical thinker is in love with "clarity, precision and is also free of pre-judgments."

Therefore, the effort to teach individuals to think criticality is less connected with the promotion of individual skills and dispositions, and more closely related to an educational action between teachers and students and among students, stimulating also the object of critical thought. This meets only demonstrably false beliefs, also in opposition to those who are at the service of the system, partisan or simply involved in preserving an unjust system of production.

John Dewey defined the nature of reflective thinking as "active consideration, persistent and careful free of any belief or supposed form of knowledge in the light of the grounds supporting it and the conclusion that tends" (1938, p.9). Critical thinking is generally accepted to issue judgments, accuracy or authenticity of several propositions, leading to a viable decision or guidance for action. The literacies for the digital age require creation, decision making and synthesis of other literacies in an understanding of the potential and limitations of information technologies. However, criticism of some situations does not constitute critical thinking, even if such criticism is relevant and well-founded. Foucault believes that criticism is an action, a way to achieve something and a virtue directed to the truth. The history of critical attitude, according to Foucault (Dewey, 1938), would rise in Christianity, through the direction of consciousness. Initially, criticism would be the art of not being so completely governable, or subjugated. Thus, the critic would be exercising their conscience and point out situations where the person was likely to be subdued by a government, religion, family, intellectual order. Foucault adds that: "criticism is the art of voluntary insubordination, of reflected intractability. The criticism would essentially ensure not subjugation of the men in the context that we could call, in a word, the politics of truth (Foucault, 1997, p.47).

In the criticism as Foucault understood it, would be possible to think of Criticism as

the politics of truth, or at least the investigation of the truth. Just the fact of critically mentioning something within the research does not make it a critical one: it would be necessary to go further, it would have to ensure an attitude of those involved through criticism. Criticism is also made with the intention of offering a broad vision.

2.2.7 Fostering critical thinking

Teaching people to think critically must include what allows them to reach their own conclusions, so critical pedagogy seems to come dangerously close to prejudging what those conclusions should be (curiously, the dangerous difference between criticizing and indoctrination). In the light of Paulo Freire's ideas (2005), for example, we see the opposite: indoctrination already exists in our schools. It is important that the students are brought to criticality, and of course we can only do this by alerting them to social conditions and power relations that provoked it. Self-emancipation is subject to social emancipation: for Critical Pedagogy, individual criticality is closely linked to social criticism, joining in the words of Giroux, "the conditions for social and therefore self-emancipation" (Giroux, 1988).

Beyond the logical and analytical skills, criticality is also the ability to think out of a "pattern" agreed by the dominant ideologies through knowledge: it means to think again, think differently. Ignorance makes the man impotent, unable to go further: as Paulo Freire would say, the duty to go beyond an "intransitive consciousness" (2014, p.60). Moreover, the purpose of critical thinking is to discern a world, a real world of relationships, social structures and dynamics that have been obscured by the distortions of ideology. Learn to "decode", to discover the real meaning of hidden things. However, it is a crucial aspect of Critical Pedagogy that dialogue does not converge to a set of agreements tied to an ability to act for social change - and social change of a particular type. Multiple, irreconcilable interpretations, by contrast, can produce other benefits - fertility and variety.

This kind of criticality also means breaking with conventions and with linear thinking, previously programmed thoughts. Tensions between radically divergent views are themselves valuable because this perspective is informative and potentially controversial: the difference is a condition for criticality. It happens in a situation that allows translation or communication between the differences while taken seriously, not detached as exotic or picturesque, and when people do not use the lack of communication as an excuse to abandon

the dialogue.

An important aspect of criticality is the ability to reflect on their own opinions and assumptions, as well as the characteristics of their particular cultural and historical formation. Such reflections by the individual should not take the form of absolute relativism, bringing the conclusion that all views are equally valid; but it brings the reflection that there is a universality or at least there must be a purpose for certain views. However, this kind of critical reflection is quite difficult to find because it is extremely difficult for humans to perceive the gaps and constraints of our own perception, then preserve most of the dialogues maintenance conditions, rules - even nonsense - to keep order. Thus, it is known that the greatest skill to develop is the ability to question and doubt even our own assumptions (Kuhn, 1993). This type of questioning is often part of the process by which the incipient critical thinking begins, with some kind of doubt, without even knowing how to move forward, freeing up the few concepts and prejudices in order to get a clearer judgment. That sense of criticality would rather go beyond what we know commonly as "being critical," and its success in the areas of school influence seems to require some patience on particular ways of thinking and acting. Could a deep sense of criticality be developed - and maintained - within the current school context? Or is it that critical thinking is threatened by the desire to achieve the good opinion of peers for their own benefit?

In the age of the Internet and the information society, critical thinking means being one step ahead of others. In general, critical thinking "is a mental activity of evaluating arguments, propositions and judgments that can guide the development of beliefs and action" (Gilster, 1997, p. 87). Critical thinking can be considered the most important skill when using the Internet, because the web circulate all kinds of information sources which are not very reliable, incomplete and obsolete. However, as in Facione,

> The cognitive skills of analysis, interpretation, inference, explanation, evaluation, monitoring and correct the own reasoning are at the heart of critical thinking. Through practice, and with good guidance, we can develop our thinking skills (such as our artistic skills, athletic or leadership), to the extent of our natural abilities

allow. Critical thinking is the judgment, reflective and intentional (Facione, 2000, p. 61).

The critical and deliberate judgment is thus directly linked to the necessary research skills in any practice, so it is essential that the student mobilizes certain skills to select, judge and criticize certain elements found in his search and then decide on them. Some theorists suggest that critical thinking skills are directly linked to the internal motivation to think and this is the result of the motivation plus critical provisions. It seems that effective teaching should include strategies for intellectual construct of thought rather than rely solely on strengthening cognitive skills.

Critical thinking is a difficult skill to be found in schools. It starts with the ability to argue (Kuhn, 1993), a simple skill, but already difficult to be perceived, and extends through a route of reflective exercises. Web searches include analysis of media texts, hypertextuality, organization, synchronous communication, interactivity, diversity, aesthetics; all in direct confrontation with the linear, with the hierarchy, conventional, logical, conventions and printing rules and, in general, audiovisual media (Livingstone, 2010; Pritchard, 2018; Castells, 2002) . Thus, we are challenged to think of scholarly research in the knowledge society differently, recognizing the media society, increasingly digital, the double challenge of responding to cybercultural literacy and sensitize students to social issues, pressing of our time. The challenge would now be to make use of technology within a questioning and critical mind-set, moreover, the web is already a very conducive place to criticism and political placements: students and teachers can participate in discussion groups and collaborative learning projects by making their own media production.

At some level, we all know what being critical means. In general, it is a good thought, often in opposition to frivolous and illogical thinking. If looked closer, therefore, there are other questions: for example, critical thinking would be closely linked to creative thinking, are they different or one is part of the other? A group of international experts were asked to develop a concept, a definition of what would be critical thinking (Esterle, 1993) and one of the first questions raised was: "who are the stronger critical thinkers we know and what features do they present to be considered as critical thinkers?" Studies of the group, after two years of research and analysis, concluded that the critical thinker has a certain amount of creative thinking, mobilizing skills to create new alternatives to a given situation,

but that is not all. The critical thinking skills were defined by the group as "the ability to assess and judge evidence, situations and arguments regardless of one's beliefs and opinions." (Ibid, p.33). So, for this study, Esterle's definition was adopted as the setting for critical thinking when the study skills were systematized by Facione (2015).

2.2.8 Core competencies of Critical Thinking

After several years of study, Facione brought together a number of usual characteristics of critical thinkers and brought these elements into their studies. These characteristics are elements of criticality and point to the critical subject. Among the features highlighted by Facione (2015) are the skills known as interpretation, analysis, evaluation, inference, explanation and self-regulation. Each of the aforementioned attributes has its definition, which for our study will be built on for the identification of critical thinking. So when seeking expression of thought the features described below, or at least a good part of them, it is possible to find evidence of critical thinking. According to these features, highlighted by Facione, the results will be analysed and we take them as the backbone of our study in order to understand critical thinking more clearly. Thus, the content analysis shall be founded on the following categorization:

a) **Interpretation:**

According to Facione, interpretation is "[to] understand and express the meaning of a wide variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures or criteria" (Facione, 2015, p.05). This happens, for example, when individuals read the expressions of a person on his face and show that they understood his mood at that time.

b) **Analysis:**

Facione raises the concept of analysis on critical thinking as "[to] identify the real

intention and inferential relationship between the statements, questions, concepts, descriptions or other forms of representation; intended to express belief, judgment, experience, reasons, information or opinions. "(Facione, 2015, p.05)

In this case, we are talking of building a way of representing a determination and the arguments and counter-arguments given to support or reject any choice. This finding, according to the description of the author, inevitably leads to an assessment of the object.

c) Evaluation:

The assessment is described as a process of "assessing the credibility of statements or other representations which are descriptions of a process; it is perception, experience, situation, judgment, belief or opinion, and evaluate the logical force of inferential, descriptions, other or questions forms of representation." (Facione, 2015, p.06)

The trial of strength of arguments or propositions would be present in a situation where the evaluation appear as characteristic of critical thinking, for example.

The features presented so far are present in many critical thinkers, but the following characteristics, according Facione (2015, p. 06), represent a critical thinker at a deeper level.

c) Inference

The author understands inference as the ability to "identify and secure elements needed to draw reasonable conclusions; to form conjectures and hypotheses; to consider relevant information statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation."(Facione, 2015, p.06).

The inference is directly linked to what is not said, it is implied and the position that the individual takes on a certain matter given, forming his own hypothesis.

d) Explanation and self-regulation

Some more in-depth critical thinkers have the ability to explain how they came to a certain conclusion and also to correct the own reasoning. They apply their own reflective and critical thinking to themselves in order to improve and adjust their own positions and opinions. Facione (2015, p.06) writing of "explanation" and "self-regulation" names these two skills.

Explanation is the ability to present a coherence to the results and reasoning. It is the ability to justify the reasoning in conceptual, methodological and contextual terms, justifying the results achieved, and to present an argument in a convincing way. When the individual can explain his or her reasoning along the development of his/her thought, it is at a more advanced stage of criticality. He can highlight naturally important points of reasoning and can also convince others about their decision-making after the process.

Self-regulation (Facione, 2015, p.07) is perhaps the most remarkable skill of a critical thinker in a deep stage. This ability becomes special because it allows strong critical thinkers to improve their own thoughts. It is a form of recursive process.

It is the ability to look back and ask yourself what was lost in the developmental process of reasoning which brought the conclusion. Here are also mobilized other critical thinking skills such as analysis and evaluation, in order to validate or correct thought. Two sub-skills are associated with self-regulation: self-examination and self-correction. Here, it takes into account the perception of who had ignored the importance of certain factors when it came to the earlier decision. It is the ability to correct one's reasoning.

Core Critical Thinking Skills		
SKILL	**Experts' Consensus Description**	**Subskill**
Interpretation	"To comprehend and express the meaning or significance of a wide variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or criteria"	Categorize Decode significance Clarify meaning
Analysis	"To identify the intended and actual inferential relationships among statements, questions, concepts, descriptions, or other forms of representation intended to express belief, judgment, experiences, reasons, information, or opinions"	Examine ideas Identify arguments Identify reasons and claims
Inference	"To identify and secure elements needed to draw reasonable conclusions; to form conjectures and hypotheses; to consider relevant information and to reduce the consequences flowing from data, statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation"	Query evidence Conjecture alternatives Draw logically valid or justified conclusions
Evaluation	"To assess the credibility of statements or other representations that are accounts or descriptions of a person's perception, experience, situation, judgment, belief, or opinion; and to assess the logical strength of the actual or intended inferential relationships among statements, descriptions, questions, or other forms of representation"	Assess credibility of claims Assess quality of arguments that were made using inductive or deductive reasoning
Explanation	"To state and to justify that reasoning in terms of the evidential, conceptual, methodological, criteriological, and contextual considerations upon which one's results were based; and to present one's reasoning in the form of cogent arguments"	State results Justify procedures Present arguments
Self-Regulation	"Self-consciously to monitor one's cognitive activities, the elements used in those activities, and the results educed, particularly by applying skills in analysis, and evaluation to one's own inferential judgments with a view toward questioning, confirming, validating, or correcting either one's reasoning or one's results"	Self-monitor Self-correct

Source: APA Report: *Expert Consensus Statement on Critical Thinking*. (ERIC ED 315 423)

Figure 2: Facione's Levels of Critical Thinking

The table above was reproduced exactly as The American Psychological Association – APA (1990) produced, in "Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction", known as The Delphi Report. It the authors' attempt to organize and systematize the work concerning critical thinking. However, critical thinking is a more complex concept than a simple list of abilities, also involving from different approaches of thinking up to considerations about the environment and procedures.

2.3. Cybernetics for Critical Thinking – a proposal in Liquid Times

Cybernetics is the scientific study of control and communication in animals and/ or machines (Wiener, 1948). This is the concept of the mathematician Norbert Wiener who reinvented in 1948 the word Cybernetics (Kubemetes in Greek) introduced by Plato. At the time Plato used the word, he meant "the art of piloting ships" and, by extension, the art of driving men and, in a broader sense, the art of governing the State (society).

For our study, we need to deepen our concept of some of the cybernetic principles to understand the complexity of critical thinking, and its networking, with its feedback system. In Cybernetics science, the systems to be studied can be circuits, a machine, a biological organism or the human cognition. In Cybernetics, it is possible to study the treatment of information within these processes as coding and decoding, reactions or feedback, learning and complex thoughts. According to Wiener (1948), from the point of view of the transmission of information, the distinction between machines and living beings, human or not, is just a detail. There is absolutely no difference between them.

The studies made from Wiener and the Researchers from different fields of science who decided work with him brought valuable contributions in many areas of knowledge. This chapter highlights the Cybernetics main principles; however, the focus will be to understand those Cybernetics contributions that lead us to understand critical thinking as an open system, explaining how critical thinking is built through our proposed model.

2.3.1. The scientific revolution

One of the most important ideas in Cybernetic concepts is that living beings and machines are not essentially different. This notion is materially manifested, especially in digital technologies, information technology, robotics, bionics and nanotechnology and the specialized technology of manipulating life (biotechnology). The relationship between body and machine inherently depends on the form of codes which determine the operation of both machines (software) and the living beings (genetic code). Products - real and imagined - of such technologies may contradict certain basic classifications such as the opposition between nature and culture, between organic and inorganic, between man and machine, among others.

The development of Cybernetics began in the mid twentieth century with a publication by the mathematician Wiener that dealt with the man-machine relationship in various fields of knowledge. The result of several years of research and interaction with researchers from various scientific fields, including the social sciences, represented in particular by anthropologists Gregory Bateson and Margaret Mead (Wiener, 1948). The idea developed by Wiener with his main collaborators, is that some functions of control and information processing are similar in machines, living beings and society. They would be, in fact, equivalents and reducible to the same templates and the same mathematical laws. The physiologist Arturo Rosenblueth and the engineer Julian Bigelow (Rosenblueth et al, 1943) also understood that Cybernetics would be a theory with a broader message, that is the "theory of transmission of messages from supply engineering". Wiener's approach was extensive, and brought together elements of different areas of expertise including those of anthropology and other social sciences. In doing so, Weiner demonstrated the interdisciplinary character of Cybernetics Science, which aims to understand the relationships between man and machine and the main consequences of such interactions including control, and feedback into the created systems. According to Wiener:

> "Naturally there are detailed differences in messages and in problems of control, not only between a living organism and a machine, but within each narrower class of beings. It is the purpose of Cybernetics to develop a language and techniques that will be enable us indeed to attack the problem of control and communication in general, but also to find the proper repertory of ideas and techniques to classify their particular manifestations under certain concepts" (1948, p.15).

Thus, we can see that an understanding of the phenomenon of man and machine and its manifestations should be at the centre of any discussion of Cybernetics. Wiener observed similarities between the performance of a human body and a machine and postulated that it is of fundamental importance to find the aspects of mathematics that regulate these systems (1984, p.24). The participation of other scientists involved in Wiener's project was decisive in making Cybernetics Science what it is today: completely open to exploring different areas of knowledge.

Systems theory, artificial intelligence, complexity theory, artificial life, cognitive science, self-organization, and molecular biology are some of the fields in the new paradigm.

After the need for disclosure and institutional space, and avant-garde image of science, cybernetics could be evaluated with greater historical distance and historiographical due care. The movement that considered bringing back the Cybernetics' contributions to Humanities begins in 1991 with the publication of The Cybernetics Group, by Steve Heims. Focused on "researchers in psychology, anthropology, sociology and psychiatry more than engineers, biologists and mathematicians", the author interprets the cyber depending on the social and intellectual context of the time, which was dominated by an individualistic mentality of an active society, best expressed as "movement of personality and culture." Heims refers to various intellectual movements, political and institutional who shared the belief that social change would come from a change in the behaviour of individuals. Bennaton says:

> The great contribution of Cybernetics was the integrator principle that puts in the same landscape living beings, nature and machines. The concept of Cognitive Ecology of Pierre Lévy (1994) serves as an important theoretical tool to understand the cognitive processes. There is a break with Cartesianism, as the key feature of this paradigm is located on fragmentation and substantiation of things. Cybernetics works with the integration of all the dimensions of life and non-life and considers the processes and not only things. The mind, learning and life are processes, not things. Therefore it would be more appropriate to say that living things are "not" but "happen" (1984, p. 45).

Cybernetics has emerged as the science providing opportunities to establish links between the various fields of knowledge in order to fill the interdisciplinary gaps not proposed, also to allow the scientific fields to share the expertise developed by other sciences. Thus, cybernetics is the science of communication and control, whether of animal (man, living organisms) or of the machine. Communication is what makes them integrated and coherent systems and control is regulating their behaviour (Wiener,1948).

Cybernetics does not propose a simple analogy between machines and bodies, it proposes a scientific practice whose principle is to treat machines, living beings and social systems as instances of the same thing. Those subjects are composed of interchangeable parts which allows, for example, hybrid systems fitted with organic and mechanical parts connected to each other or machinery fitted with "artificial intelligence", reproducing and, for some, overcoming the college which is traditionally distinctively human.

Several authors researched about the logic in Cyberculture: Gray, Mentor and Figueroa-Sarriera (1995, p.2) write about "the fusion of organic and machines, or the union of engineering between separate organ systems". To Hayles (1999, p.3) "the post-human

subject is a mixture, a collection of heterogeneous components, a physical-informational entity whose borders remain in continuous construction and reconstruction". Haraway (2000, p.313) reminds us "there is no fundamental ontological separation, in our formal knowledge between machines or bodies, between technical and organic"; to Escobar (2000, p.62), the borders between the organic, the techno-economic and textual produce "assembly or machine mixes, and text body."

Science has observed a significant movement in the past two decades, going beyond the borders of determinism, like Chaos Theory and the consequent approach to Complex Dynamic Systems and Self-Organization, once reviewing or revising its principles and theories. Many areas of knowledge has been influenced, as states Prigogine (2002), from cosmology to economics, the knowledge of chaos and complexity allows the arising of new paradigms, which are important for the imminent development of research in all areas, from a holistic perspective.

It is important to emphasize that the scientific approach provided by Cybernetics, left its ideological residue in our Society (Conway, 2005). In Social Sciences, what remains of Cybernetics seems to be the result of a conventional amnesia. The apparent lack of knowledge about the numerous techniques of data processing and the apathy related to the concepts that precedes it reinforce a non-standard production that features the academic production in areas related to sociology, anthropology, social psychology, political science and communication. In academic's common parlance, Cybernetics is just a prefix, a linguistic resource used to mimic new technological terms. It is more important to say that, recalling the words of Martins (2005), the knowledge that arose by Cyberneticists researchers within the scientific community is so wide. To deny its penetration and consequent influence on our understanding of Human interaction and learning, would be an act of superficial ingenuity.

2.3.2. First Order Cybernetics

In the first ideas of this scientific approach, the emergence of an information theory received important contributions from the work of scientists interested in the unification of sciences and their legitimation from the structuralist point of view. The greatest asset of this incursion was to establish a consistent philosophical apparatus and to include information in the category of quantifiable objects by transferring and transposing techniques and models

from the natural sciences (Mattelart, 1999)

The mathematician Norbert Wiener is considered representative of the theoretical framework of first-order Cybernetics (Mattelart, 1999). The direct association as "father of modern cybernetics" was attributed to him due to the dedication given in the elaboration of a method able to describe and measure the quality and quantity of information exchanges from some electronic experiments (Flo and Siegelman 2005). The book Cybernetics, published in 1948, was acclaimed as the foundational work, from the technical point of view, of this "new science".

The information concept is the hard core of Cybernetics. What has been done in the studies that involve Cybernetics is to limit the information from the scientific point of view, admitting that every concept is a planned construction. Many scientific concepts are far from a consensus (Copeland, 2015). Similarly as any other scientific concept, variation serves less to affirm its moral characteristics (positive, negative, or neutral) and more to find a reference point, while considering its performance.

2.3.3. Second Order Cybernetics

First Order Cybernetics used the delimitation between observer and system for almost thirty years of existence, using the definition of these two entities being distinct, where the first one would not interfere in the reality of the second one. Second-order cybernetics recognizes that phenomena and subject cannot be treated separately. Cybernetics, as a science, begins to understand that systems cannot be organized from outside. This approach used to exclude the possibility of the observer being such objective in his observation of an independent reality, leaving the system free from the influences of the observer. The notion of self-reference is fundamental, in Second Order Cybernetics, building the idea that the observer is inserted in the observation made by him: the person that describes his observations describes himself. First Order Cybernetics did not bring this idea, where it understands its models as corresponding to a reality independent of the observer.

About 30 years after the founding of the first cybernetics, Heinz Von Foerster (1991) proves the versatility and power of cybernetics when he applies it to himself (Cybernetics of

Cybernetics), and with it brings attention not only to the object of control or of the systems observed, but specially defines the importance of the subject that observes the observed systems. In particular, Von Foerster shifts the focus of attention right on observant systems. He called his new approach as the Second-Order Cybernetic, which includes some important differences from the first order, such as the emphasis on emerging processes with a greater degree of uncertainty but organized around life and survival, self-referral, self-organization, resilience (Turchin, 1995).

For Brier (2015), there are some very interesting similarities between Second Order Cybernetics, Cognitive Biology based on Autopoiesis, and Semiotics. Second Order Cybernetics included the observer in the observed systems. As the cyberneticist Heinz von Foerster named: "The Cybernetics of Cybernetics" (Foerster, 1974). With second order Cybernetics, the subject and his reflexive subjectivity, which for centuries had practically been left out of the dominant paradigm in the sciences, returns with a more founded look at biology than in engineering, bringing deep interest in intelligent flexible forms and adaptation, than in the control of processes (Holland, 2004). Still, in the rigid structure of the scientific field, the acceptance of these perspectives has not been easily accepted. The very recent history of the social sciences can document the resistance that for many years the associations of "traditional" scientists - as well as the first - have had against this second cybernetics.

From these perspectives and intellectual tendencies, socio-cybernetics has begun the process of being recognized within the areas of sociology. After have being confronted with multiple prejudices and fearful animosities of the sociological field, finally and after years of struggle, achieved its recognition in 1994, in The 13th World Congress of Sociology in Bielefeld. In one of his clearest presentations, Felix Geyer describes it as "the application and development of second-order cybernetics to social processes" (1995).

2.3.4. The Cybernetic System

The introduction of the feedback idea breaks with linear causality and points to the idea of a causal circle where **A** acts on **B** which in turn acts on **A**. Cyberneticists used a principle of control engineering, which has been called feedback, to support the idea of obtaining response from systems. In this way, it would ensure that the projectile's route was, in fact, successful. The feedback system provided compensation for possible deviations in the

mechanism's performance in order to correct future errors. What is important in this study is the idea of a self-organizing Cybernetics system.
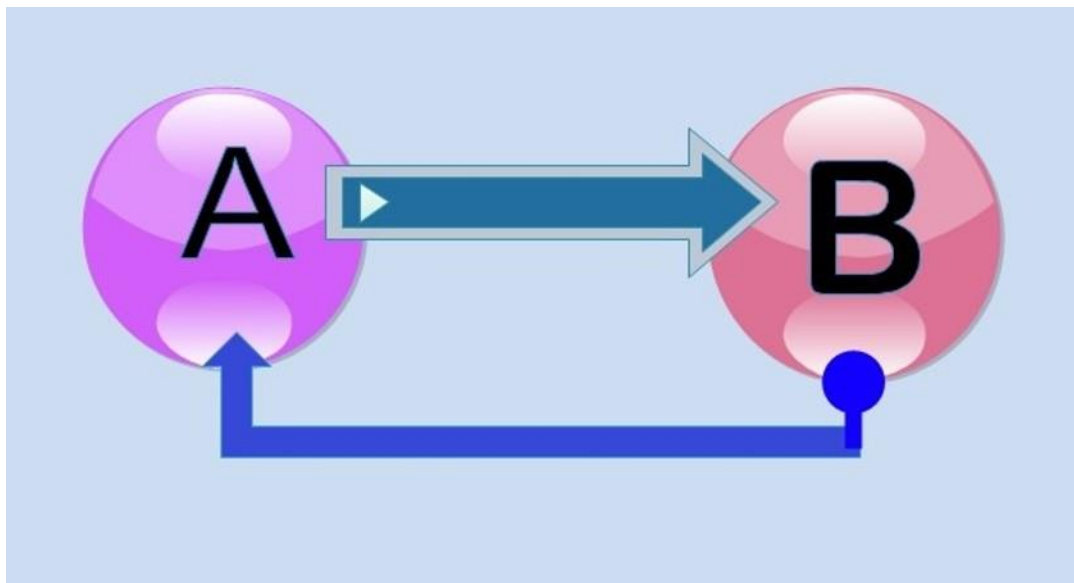

Figure 2.1: Cybernetic feedback

The Cybernetics system's **feedback** can be classified as positive or negative. Negative feedback can be seen as an error message, meaning a deviation from the expected level; the system adjusts it by reducing or neutralizing the misapplication. This is the most important form of feedback for homeostasis, since the principle of deviation-neutralization of deviation is the focus of traditional cybernetics.

Positive feedback is also a response to error. However, the system can extend or maintain the deviation (Epstein, 1986). This type of interaction is important in morphogenesis, or system development (eg in learning). Positive feedback leads to oscillation and system collapse. The inflationary cycle in economics is one of numerous examples of positive feedback effects.

Advanced have more complex feedback systems. They involve a series of hierarchically ordered subsystems and at any time, a subsystem can be part of the larger system or be part of the environment. In addition, is known that subsystems respond to each other in mutual interdependence (Epstein, 1986).

2.3.5. Cybernetics principles

It is possible to observe a new scientific paradigm that challenges the scientific community to abandon some simplified practices inherited from Cartesian-Newtonian paradigm. These procedures brings few answers to very complex fields such as cognitive science, for example. Thus, issues related to cognition and construction of subjectivity may find in complexity an important approach, dealing with chains of relationships which are included in the different aspects of human reality.

While the history of science evolved, it entered a branch with the new paradigms of thought, mentioned earlier, and it influenced a new era of information, Cybernetics. Cybernetics brings out man's relations with machines in a communication study and management information inserted into the systems theory of context. Ashby (1970) states that cybernetics,

> "(...) offers a unique vocabulary and a unique set of concepts with adequate representation of the various types of systems (...), it will probably reveal many parallels relating the machine, the brain and society. In addition, it can provide a common language, which can be readily used in other sciences. "

A seen, is possible observe the human thinking formation as a complex system. Those Cybernetics concepts and vocabularies will help to understand and build a strong model for comprehension of human critical thinking.

a) Entropy

The cybernetic principle of entropy is derived from the second law of thermodynamics, originally. While in Thermodynamics, it means an ongoing process of order reduction within a system, consequently increasing its chaos, implying that social relationships cannot remain the same for a long time. Through friction, the energy is lost. Thermodynamics arose as the "study of the efficiency of machines" and its most famous principle states precisely that there is no perpetual machine (Joslyn, 1991). The entropy of an open system is always increasing. In other words, it will become degraded quickly. The universe, which comprises life and thought, is an open system and the modern cultural world has become open itself: a whole Planet without borders.

As a cybernetics scientist, Bateson developed a number of theories about the social relations that handle communications and interactions between members of a chain, marked by roundness, swings and limits (Poster, 2001). This brings us to the cybernetic 'Principle of Entropy', that is the idea of having an uninterrupted and regular process of reduction of organization in a system, increasing its chaos; in other words, the relations within a society or a group do not remain the same over a long period. "Another way to explain the situation is to say the total amount of energy is conserved, but not its quality" (Brillouin, 1949).

In analogy to the structural concepts of Durkheim's mechanical and organic solidarity, Bateson used cybernetic theory to argue that the social dynamics were for mankind as part of a mutually casual biosphere. Inside, life is organized from a complex communication system and determined by symmetrical and complementary relations. Bateson named this interactional phenomenon "schismogenesis", as "a process of differentiation resulting in individual behaviour standards of the cumulative interaction of individuals" (Bateson, 2006, p.219). He considered the principle of entropy as circular and continuous system for balance between order and chaos, associating social relations as a communication system with recursion interactions characterized by roundness, swings, dynamic range and feedback and therefore constantly changes (Rapport & Overing, 2000) .

The theory of Laing (1976) on the "divided self", according to Rapport and Overing (2000), owes much to Bateson's ideas about schizophrenia with "double bind" communication. The work of Goffman (1961), about the maintenance of social structure and reality through a socially sanctioned process through "situational encounters" and a "situated activity system", had a distinct connection with cybernetics.

The second law of thermodynamics states that the entropy of a closed system always tends to increase up to the level where it is no longer possible to make any useful caloric exchange. At this point, it is known that the system has reached the thermal death. The interpretation of entropy is also associated with the system's level of disorder, where the system goes from a state of maximum differentiation for a disorder, while this disorder is associated with an extremely increased internal entropy.

According to Prigogine (1976), the complexity increases because the entropy does not bring the world necessarily to death but to greater complexity and disarray. In systems far from equilibrium, entropy production is so high that the local entropy reduction can occur

without violating the second law of thermodynamics. Under certain circumstances, this mechanism allows a system to self-organize spontaneously. Prigogine and Stengers state the dissipative systems that would have a rapid transformation from seemingly chaotic to progressively organized at the other end of the two possible ways. They use material energy or human labour and return them to the environment as heat. They are, in principle, "systems out of balance" (the exchanges between the external environment and entropy internally produced are not equivalent), based on the exchange, only: this change leads to more complex organizations, and systems to "learn" and evolve.

The cybernetic Principle of Entropy applies, therefore, to various existing systems and organisms. These include the Education Field and Education System, which have become surrounded and infiltrated by Digital Artifacts, Digital Natives (Prensky, 2001) and their own associated language. Despite these additions, the educational system has all too frequently been preserved, like models of the eighteenth century: chairs in a row, teachers in charge, classes scheduled and structured to make students think and react as the teacher instructs. However, the destabilization of the current educational model is now occurring more rapidly, according to the Principle of Entropy as stated above. In this situation, researchers in education must propose suggestions to stabilize this system and with this in mind "The Law of Requisite Knowledge", another of the principles of Cybernetics, is considered.

b) **Principle of Selective Retention: early deterrence**

A complex system consists of a number of distinct substructures subject to variation. As the variation is not absolute or complete, these substructures must show some invariance or stability. The principle of variation and selective retention (Heylighen, 1988) was elaborated from this point of view. This means that the substructures will not change all at the same time. There is some form of inertia or continuity that limits change. This allows us to consider a substructure as possessing a stable identity over a certain (perhaps infinitesimal) span of time. What can then change during this interval? Both the relationships or connections between the substructure considered and the others as well as the internal organization of the parts of the substructure change. The first process may be called (re) combination and the second mutation.

The principle is simple: "stable settings are maintained, and the unstable are disposed"

(Lindgren, 1969). Stability is understood as something that does not change or fade easily and which can be maintained in the system, whereas instabilities are things that are more easily removed from the same system.

Socially, the role of school, students and teachers, needs to be changed. The students need to be encouraged to learn through experimenting, creating, challenging and sometimes "teaching" their teachers something they have learned (Gasevic, 2015). The school needs to adjust to new times but still keep its principles, and teachers need to adopt and adapt to new teaching practices. Issues are bound to arise, for example, what should schools/teachers do with students who "know more than the teacher" in terms of digital technology.

Perhaps reflective of the increasing availability of different types of information, a growing interest in informal learning is being observed (Bauman, 2016). Whether this takes the form of a student searching the Web for information or undertaking a tutorial on how to fix their own mobile devices, twenty first century learners have built their own learning styles, with learning performed in many different ways and for many different reasons. Facilitated by technology (Shepard, 2000, p.10) learning is becoming increasingly self-directed, internally motivated, and no longer related to time, place or formal learning structures.

Habermas (1971, p.13) deals with learning as a collaborative act between the partners including peer groups. But, what about when "peers" are technological artefacts and digital media? Do students learn less? What should be done in this new situation where social theories do not seem able to predict the interactions between man and machine as generators of knowledge? Noting that digital platforms and interactions between man and computer foster logic skills and those of criticism in students, causing them to develop their critical thinking, there needs to be reflection on the new roles to be played by the school and teachers from now on. Contrary to what many may think, "the school as we know it will end", as the educational system and roles within it become more complex, requiring more expertise from the teachers in the 21st century (Valle & Abranches, 2011).

The principles of Cybernetics may be helpful in the understanding of the man/system interface, whether this system is a machine, a living organism or even a phenomenon. In this section, two cybernetic principles will be used to propose the theory and validate a model that can explain the critical thinking phenomena stimulated by digital technologies; these are the Principle of Selective Retention and the Principle of Asymmetric Transitions: Entropy (Heylighen, 2007).

2.3.6. Cybernetics, Education and cognition

The first movements towards a new science, called cognitive science, happened in 1948 at the California Institute of Technology where the classic question of discussion was how the central nervous system controls human behaviour. Beyond this approach, as Varela et al (2017) say, this conference was especially important for a few reasons: the connection it made between brain and computer; and the challenge it proposed to Behaviourists. Positive-oriented Behaviourism, whose main idea is based on the analysis of observable behaviours, avoiding "mental" concepts, took place during the 20s and 40s. By not attempting to explain cognitive processes, Eysenck and Keane (1994) highlight they tend to be superficial, from which arose lots of questioning and doubts. At the Hixon Symposium, John Von Neumman – mathematician, Warren McCulloch - neurologist and Karl Lashley – psychologist introduced some theoretical inputs, establishing systematic comparisons between the functioning of the human brain and electronic computer type machines.

In the past century, in the United States, the first electronic computers, were created to operate with the numbers of World War. According to Rode (2017), Alan Turing, in 1936, conceived the idea of a simple machine that used logic to perform calculations. Further on, Turing suggested the development of a machine that simulates human thinking, implemented by Neumann with the storage of a program in memory. From these studies, Claude Elwood Shannon, an American mathematician, in the late 1930s, formalized the concept of information theory. According to Shannon's information theory, information could be reduced, as well as the true and false terms of propositional operations, to a binary digit. It is necessary observe that Shannon's entropy has a different approach than Thermodynamics.

It was Wiener's insights that brought Shannon to the proposition of dissociation of information and its transmitter. "*Information is information, not substance or energy. No materialism that does not admit it can survive today*" (Wiener, 1961). An analogy between neurons and logic by Warren McCulloch and Walter Pitts stated that the human cognition could be conceived in electrical terms – as signals that pass or fail to pass through circuits. As a result, computer science started to research on neurons and their connections to design machines or programs increasingly similar to the human brain.

However, the recognition of cognitive science by almost unanimous consensus and the academic community came about from the Symposium on Information Theory held at the

Massachusetts Institute of Technology in September 1956. In the following decades, there were several movements to study cognitive science, with many book publications on the subject.

Neumann revolutionized the design of a computer's operation, when he said that it was possible to put instructions and data in the same place, not requiring the use of two memories. In computing circles, the term "von Neumann architecture" is well known, which defines the architecture that allows autonomy between hardware and software (Faust et al, 2015). At the same time, Norbert Wiener presented the term "Cybernetics", a definition that tries to deal in mathematical models with all human psychological activity. He emphasized the need for machines to follow the functioning of the living organism in the control of their own activities. After the cybernetics years, the possibility of designing programs that simulated intelligent behaviour came through the expression "artificial intelligence" coined by John McCarthy on the campus of Dartmouth College in Hanover.

Artificial Intelligence provided the fundamental step for attempting to relate minds and computers and establishing the "computational model of the mind" (Varela, 2017). It is not completely known whether its purpose was fully realized, but, as Varela says, it forced the scientific community to think about and develop important concepts like intelligence, consciousness and many other concepts that are often employed by philosophers and psychologists. Another group of critics was related to human beings' ability to create problem-solving creative solutions, while computers would only repeat predefined processes.

As Copeland (2015) reports, philosophers such as John Searle, among others, were concerned with questions like "can machines be endowed with intelligence comparable to human intelligence?". Facing this challenge, scientists and computer engineers came to endow the machines with "artificial minds," following the models defined in the cognitive sciences. Different theories have emerged in Artificial Intelligence, due to the lack of definition of the main concept of human intelligence. Among them, Vignaux (1995) questioned whether it was necessary to provide the computer with an avalanche of data, or whether it was necessary to base the study of cognition on the lower level of perception. Reconciling these two aspects in a third hybrid theory, according to which the machine would be able to reason using complex concepts and to perceive their surroundings. By the 1940s there were two extant paradigms related to Artificial Intelligence, the symbolic and the connectionist. The Symbolic Artificial Intelligence privileged to study the human mind, using

simulations and mental representations through autonomous programs in relation to the hardware. Artificial Connectionist Intelligence believed that by constructing a system that simulates the structure of the brain, this system will present intelligence, that is, it will be able to learn, assimilate and learn from its mistakes.

The neural networks, representatives of the second paradigm previously mentioned, consist of a system with circuits that simulate the human brain, including its behaviour, being able to learn rules. Such networks constitute an intricate set of connections between neuron-like units that are arranged in hierarchically organized layers. According to Copeland (2015), the connectionist approach brought a new vision in the attempt to construct a model of the mind, based on neural networks. Despite the computational limitations of the time, some important achievements were highlighted, such as the emergence of Cybernetics, the modelling of neuron networks as a new paradigm for computational architecture and the development of some intelligent computational programs that mimicked human behaviour.

The similarity of concepts between Cognitive Science and Computer Science arises from the first generation of scientists, who believed in a science of cognition shaped in the image of the computer. As Cecconi (2016) states, there could be cognitive science without the computer, but it would not have arisen when it emerged, nor taken the form it took, without the appearance of the computer. The facts intertwined throughout history, creating an intersection of visions where the mind follows the functioning of the computer and the computer seeks the functioning of the mind. Still, Cognitive Science is a hotly-debated area that is still trying to establish its own paths - an area where consensus is still a long way off (Teixeira, 1998). To overcome this problem, an integration between the various approaches to the study of mind and brain is necessary. Computer Science, in turn, has sought to simulate human thinking in its essence, a task that is not very easy, but one that has been improving over the years and currently works with the concept of neural networks. Specialist systems that peaked in the 1970s and 1980s have resurfaced with this approach, combining conventional architecture with a connectionist architecture. In this sense, scientists are increasingly using the computer as instruments of data analysis and as a laboratory for the simulation of cognitive processes. But as Cecconi (2016) discusses, there are still some scientists who consider it a mere toy, disrupting rather than accelerating efforts to understand human thinking. In the fields of linguistics and psychology there are still reservations regarding the computational approach. In this context, Cognitive Science,

because it presents a multidisciplinary element, can seek the integration of knowledge about the study of the mind, finding a unified theory of cognition, together with scholars of several areas of knowledge. The great challenge of Cognitive Science continues to be to make conceptual and empirical progress that allows us to know what we are talking about when the reference is the mind or the consciousness.

2.4. Conclusions and Emerging Research Questions

This chapter has explored the key concepts related to this research, such as Critical Thinking, Use of Technology in schools and Cybernetics principles that have been used to understand the Critical Thinking phenomenon, and it has introduced the theoretical framework which underpins this study. It has also pointed to the necessity of forming critical thinkers in the Digital Age, understanding Critical Thinking from the Cybernetics perspective. The use of technology in schools and the emerging of another way of dealing with the children at schools, understanding minds and surroundings, brings an excellent opportunity for this thesis develop these concepts and offer new perspectives, either theoretically and methodologically.

The greatest research questions expressed by the concerns surrounding the research problems presented are important and relevant to the citizens of the Digital Age: how is human critical thinking fostered in Digital Age? Is it possible to propose a model for critical thinkers from Third Millennium, using cybernetic and cognitive science, combined? Would this model be valid for conception of human critical thinking in non-digital societies? These questions and concerns guided this research to objectify a relevant academic contribution.

Chapter 3

Research Design

3. Research Design

This Research has been structured in two different data collection moments. First, a Pilot Study, was performed at 2011, with school children from seven to eleven years old. Second, a Main Study was performed with the same research techniques, on 2016, with children from twelve to fourteen years old. We opted for a Research Technique protocol as a data collection instrument and adapted the Clinical Interview research technique to Digital Devices, as the more appropriated research method to reach cognitive area. This chapter gives the necessary justification for the approaches taken.

Epistemology is the area of philosophy dealing with the theory of knowledge. It attempts to provide answers to the question: "can we know the 'how' and 'what'?" It means thinking about the nature of knowledge itself on its scope and on the validity and credibility of knowledge. Several research methods provide efficient ways to approach and understand research problems. However, it is necessary to be clear about their goals and also have a sense of what kind of elements can be discovered. In other words, the researcher needs to adopt an epistemological position.

To Gialdino (1992), "paradigms" are theoretical and methodological frameworks of phenomena interpretation created and adopted by researchers aiming to find a philosophical worldview to determine one or more ways to access reality, as the adoption or elaboration of concepts or theories that are believed to support the comprehension of a phenomenon; the social context in which the researcher is found. They include the researcher's form of existential commitment; and the election of the phenomena to be analysed.

For the same author this way of defining paradigms is more accepted in the social sciences, especially those who rely on positivism adopted in models which can form these paradigms. To Kuhn, "Paradigms are universally recognized scientific achievements which for a time provide model problems and solutions to a scientific community." (Kuhn, 1971 cited Gialdino, 1992 p.25).

Paradigms can be understood as guidelines through which the researcher explores the world and therefore conducts investigations. In this sense, the methodological choice usually involves ontology and epistemology on the paradigm with which it identifies (Feitosa and Popadiuk, 2009). Being located in a particular paradigm means seeing the world in a particular way. The paradigms are related to visions of the social world based on different meta-

theoretical assumptions about the nature of science and society (Burrell and Morgan, 1979:24).

The paradigms as defined by Kuhn, are themselves part of a positivist framework. It assumes that there are general laws that govern the phenomena, including the social; constancy and regularity should be sought which would allow the formulation of laws, generalizations and predictions.

New questions took place at the end of the last century, where it was possible to observe significant changes in values among all levels of society. The different disciplines of study of human life underwent concerns, revisions and redesigns. Small "clean studies" did not produce the answers claimed by social demands. For these "clean studies" according to Bruner (1997), there are forbidden topics such as the intentional states, the meanings, constructions of reality and its mental rules among others.

The use of methods or designs with mixed multiple research is a growing trend in sciences in general. The combination provides methods helping an alternative approach to the often complex problems faced by an equally complex society. Discussions about the use of more than one method begins with a review of design principles, specific mixed or multiple methods.

The research methods were the questionnaire, the Clinical Interview that was adapted for Digital Devices to perform the Research Protocol as Data collection instrument. The data analysis instrument was the Content Analysis.

3.1 Methods and approaches

3.1.1 Case Study

According to different authors (Lakatos, 2003; Stewart, 1997), the case study has its origin in medical research and psychological research, with the detailed analysis of an individual case that explains the dynamics and pathology of a given disease. With this procedure it is assumed that the knowledge of the phenomenon studied can be a model towards understanding the exploitation of other cases. In addition to medical and

psychological health, it has become one of modalities of qualitative research in the human and social sciences. As seen by Gillham (2000), the case study considered as the research modality, its origin is quite remote and relates to the method introduced by C.C.Laugdell in legal education in the United States. Its diffusion, however, is linked to the psychotherapeutic practice characterized by reconstruction of the individual's history, as well as the social workers with individuals, and communities. Currently, it is adopted in research of phenomena from the most diverse areas of knowledge, also can be seen as a clinical case, a psychotherapeutic technique, didactic methodology or research modality.

For our study, is possible to define the Case Study according to Stake's (1995) paradigm. Stake (1995), while defining *case,* states it is "a specific, a complex, functioning thing," working like "an integrated system". This system "has a boundary and working parts" (in social sciences and human services) (p. 2). This is the proper holistic nature of the qualitative research, aiming to look at a phenomenon and its bias, considering the relationship between the phenomenon and its contexts. In the same context, qualitative case study is a "study of the particularity and complexity of a single case, coming to understand its activity within important circumstances"(p.11).

Case studies have several applications. However, they seem appropriate to investigating phenomena where there is a wide variety of factors and relationships that can be directly observed and there are no basic laws to determine which of them are important. A great benefit of case studies is found in exploratory research. Because of its flexibility, it is recommended in the early stages of an investigation of complex issues, for the construction of hypotheses or reformulation of the problem.

The Case Study is also pertinent in situations where the object of study is already sufficiently known to be framed in a certain ideal type, as was the case of this research. New discoveries are also useful in the exploration of new processes or behaviours because they have the important function of generating hypotheses and constructing theories, also exploiting atypical or extreme cases to better understand the typical processes. Given the complexity of the topic proposed in this study, the case study brings a good background to the research questions and provides the construction of an adaptive methodology in order to understand the phenomenon to be studied.

Based on the presented applications, the advantages of the case studies are evidenced: they stimulate new discoveries, due to the flexibility of ~~its~~ planning; emphasize

the multiplicity of dimensions of a problem, focusing on it in a holistic view and relatively simple procedures, as well as allowing an in-depth analysis of the processes and relationships between them.

There are also limitations. The most serious seems to be the difficulty of generalization of results obtained. It may happen that the unit chosen for research is quite atypical in relation to many of its species. For this reason, it should be remembered that although the case study is relatively simple, it may require the researcher to be very attentive and careful, especially since he is deeply involved in the research. Thus, the most common arguments of the critics to case studies are the risk of the investigator presenting a false certainty of their conclusions and relying too much on false evidence. As a result, the researcher may fail to verify the reliability of the data, categorization and of the analysis performed. The most appropriate way to eliminate the study bias is to develop a case study plan that prevents probable subjective misunderstandings.

There is yet another misconception about the application of the case studies that should be mentioned. It is the understanding that, using one or a few units, represents a very easy research to be carried out. This statement simplifies the level of complexity involved in this research modality and the scientific rigour necessary for its planning, analysis and interpretation.

3.1.2 Explanatory Research

According to Yin (2003), there are three types of case study research: exploratory, descriptive, and explanatory. The previous study that originated this research (Valle & Abranches, 2011) has been established as an exploratory research. The main objective of the exploratory research is to provide better familiarity with the object. Often the researcher does not have sufficient knowledge to formulate adequately a problem or elaborate more accurately a hypothesis. In this case, it is necessary to "initiate a process research that identifies the nature of the phenomenon and points to the essential characteristics of the variables that one wants to study " (Lakatos, 2010, p. 126).

For this study, the main objectives can be better qualified as an Explanatory Research. The explanatory research has a fundamental concern: identifying factors that contribute or act as cause for the occurrence of certain phenomena. This is the research type that explains

the reasons why and explains a complex occurrence.

> Scientists are not limited to describing the facts in detail, they try to find their causes, their internal relations and their relations with other facts. Its purpose is to offer answers to questions, to whys. It was formerly believed that explaining scientifically was exposing the cause of the facts. However, it is now recognized that causal explanation is only one of the kinds of scientific explanation [...] (Lakatos, 2010, p.29).

The explanatory research may work as an experimental research and case control study (Kendall, 2003). It can be said that scientific knowledge is based on the results offered by explanatory studies. This does not mean, however, that exploratory and descriptive research has less value, because they almost always constitute an indispensable preliminary step in order to obtain scientific explanations. An explanatory research may be the continuation of a previous descriptive one, since the identification of the factors that determine a phenomenon requires that it is sufficiently described and detailed. Explanatory research in the natural sciences relies almost exclusively on the experimental method. In the social sciences, the application of this method has many difficulties, which is why other methods, especially observational methods, are also used. It is not always possible to carry out rigidly explanatory research in social sciences, but in some areas, especially in psychology, research has a high degree of control, even being called "almost experimental".

3.1.3 The Ethnographic Element

The ethnographic method is composed of many procedures including probabilistic and quantitative research data collection (demography, morphology, geography, genealogy). However, direct observation is undoubtedly the privileged technique for investigating knowledge and practices in social life. It is also important to recognize collective actions and representations in human life, an engaging experience of perceiving social, cultural, and historical contrasts. The first insertions in the universe of research known as "exploratory exits" are guided by the attentive look at the context and everything that happens in the space observed. Curiosity is soon replaced by inquiries about how social reality is constructed. This is inhabited by comparative aspects that arise from the dense insertion of the researcher in the commitment to reflect on social life, being above all willing to experience the experience

of inter-subjectivity, knowing that he himself becomes object of observation (Lévi -Strauss, 2013). The researcher compares the aspects that he / she perceives increasingly oriented by theoretical-conceptual issues learned already in the first years of the course of human sciences.

The foundations of ethnographic practice, therefore, brings role of the researcher in the area of social sciences in the investigation of social life in the centre of the discussion, especially in the 1950s and 1960s, more particularly when the object of anthropology migrates from so-called primitive societies to the societies of anthropologists themselves (Clifford, 1980). The role of the ethnographer concerning to the object/reality observed, his level of intimacy, his position while participating in the processes of social life that changes and transforms in time and space, relies in the delimitation of the fieldwork according to the situation that the researcher occupies to the ethnographed phenomenon. In anthropology, the dissimulation of the ethnographer (his profession, his objectives, his intentions, etc.) within the group to be investigated unleashes ethical-moral inconveniences that have been debated by his community of researchers who tend to reject the situation where the anthropologist hides his or her true intentions in the field. The researcher in disguise figure is therefore rare in the practice of the ethnographic method, once it used to put in jeopardy precisely the pact of trust and complicity with the group that investigates and from there compromising the nature of the data obtained by him. The ethnographic method operates precisely with this infinite distension of the researcher before himself and the other, being within this void of meaning that springs his reflection on human cultures and societies. It is important to emphasize that the duration of an ethnography is not the same as the duration of the temporality of the social and cultural phenomenon itself investigated.

It is necessary to consider the ethnographic element in this Research. In order to access better results, it was necessary to know more about school's methods and approaches. It would not be possible to evaluate the impact of the Habitus with no understanding of teacher-students' relationships at school. However, the Researcher just got in touch with students at the moment of Clinical Interview and while it lasted.

3.2 Data collection tools

For this research, there were different kinds of data collection instruments: a semi-structured interview, the preliminary study with students, observing the activities with mobile devices at school, and the clinical interview, which has been adapted from the technique developed by Piaget to contemplate the students' critical thinking.

Initially, there must be some observations in school in order to better understand the main objective and realities and build an effective and meaningful task for the Clinical Interview. For verification of critical thinking or at least critical evidence in students, we chose the clinical interview.

3.2.1 The research protocol as data collection instrument

There is a tendency at schools, in general, to look at classroom research only as an evaluation tool, in the more traditional forms of non-formative evaluation, ignoring its constructive and elaborative elements (Freire, 1985). So while thinking about research through the Internet, some school agents prefer to completely ignore the existence of cyberspace: the research remains exactly as previous generations used to do using encyclopaedias. Still, these technologies remain out of the classroom.

How, then, could the current educational system be adapted to technological innovation? It is necessary to rethink the whole approach, since even the texts on the web have a different dynamic (Marcuschi, 2005). When young children search the internet, for example,

> rather than reading the short descriptions provided in most search results, students will most often consult the first link provided by the system and work their research through the list, following the linearity (Guinee 2003, p.363).

Thus, this means unnecessary time and effort; it is not the most efficient strategy to access relevant information. Recent studies show mixed results when the subject is technology in the classroom, making a definitive conclusion difficult and there is no consensus about its application (Schacter, 1999).

The great motivating agent of research should be the very taste for search, for discovery; for the teacher, it should be "teaching to learn". The problem is that in most cases learning to learn is designed only as mere problem solving, focusing only on identifying and correcting errors in the external environment. Solving problems is important, but this type of learning that involves critical thinking is more than merely identifying and correcting something: it means learning to look into yourself, as well. Subjects need to react critically to their own behaviour, identifying which aspects of their *modus vivendi* can contribute to social problems – from throwing an empty package on the floor to acting unethically in their daily lives (Morin, 1996). The heart of all this problem should be "reflection" as the central point of the whole problem with research: teaching "to reflect on" is sometimes more important than memorizing data on a given topic.

According to Demo (2006), school research in modernity should have as its main basis the "reconstructive questioning". It should be a dynamic, systematized approach to the teaching processes faced in the classroom. While a concept or knowledge is questioned, that concept is destroyed to be rebuild through its reconstruction. During the research, questions arise by placing truths until then considered as absolute in check, allowing the process of concept reconstruction and re-elaboration of knowledge.

During the process of reconsideration of this knowledge, the arguments for certain positions are reassessed. Each researcher needs to state the reasons why he or she is convinced of their truths, and this is not always easy. This makes the student, a former observer, passive in front of the school reality, to be an active subject in the search of his knowledge. On the other hand, the teacher ceases to be the holder of the knowledge, monopolizing his process of reproduction, to become the one that guides and redirects the questions and the searches of the students. According to Paulo Freire (1996), the act of teaching should be an attitude of openness to the questions and curiosities of the students, still being critical and inquiring. The teacher, therefore, must be open-minded and prepared to work with (genuine) research in school.

Once again, our multimedia society signals that our young people must be prepared for a world of great and continual changes. In this society, knowledge is "volatile", no longer considered, as it was decades ago, an "acquired patrimony": it is in constant transformation, occurring its vertiginous updates. Thus, our student must have as a central habit to always seek updates and re-elaborations of knowledge, within their social reality.

Still, as far as the media society is concerned, it is worth remembering that this same society is characterized by an abundance of information, which has as a central problem for the student researcher to decide what is sufficient and reliable information, bringing the challenge of selection of information as an initial challenge. The student must develop these skills in order to overcome this selection phase, but also to find meaning in countless, sometimes inconsistent messages.

Through the discussion of the topics raised and the questions proposed by the research, is possible to raise meanings and reconfigure the information and sources. A person can then perceive collaborative learning (Barkley et al, 2014) and the arguments are verified. The dynamic must share the group's interests, so that everyone feels interested in sharing knowledge and information. This process must validate research, within a consciousness that all knowledge is changeable, flexible, subject to new conclusions.

Pedro Demo (2015) emphasizes the importance of learning based on what he calls constructive questioning, which would ground the formation of the individual's critical thinking. For the student, the critical reading of the world is a result of this awareness that is formed by self-knowledge, the ability to defend his ideas, and by his motivation to pursue the search for new questions.

The research protocol has been built following these principles. The school research cannot be only a data collection. Students can do more than only ask something to a search website and searching. They can bring different point of views for the same data results, check what they found differently, discuss the questions and produce a new idea, another result, which has been completely built by them. This production can be a video, a blog, a text, a song, anything that can indicate these young people are applying their knowledge to produce more knowledge. The deeper critical thinker skill is the ability to correct one's own thinking: only strong critical thinkers can do that. It is possible to build an activity to mobilize critical thinking skills if schools rely on research as an educational principle.

3.2.2 Clinical Interview

The clinical interview is the pioneering technique developed by Piaget (1975) to study the form of knowledge structures and thinking processes. After a while, it has been rediscovered as an useful research technique and, from the past 25 years, it has evolved to a variety of methods, including open interviews and problem solving protocols. Much research in education has been made to perform some procedures around pre-defined tasks, recorded and later analysed after the child endeavours to perform some operations. The teaching practice, otherwise, assumes that children are not able to build the activity, the way to solve it, and the solution in other ways that are available in a certain level to the child's development. In other words, children must interpret the task and try to build a solution based on the data or skills that she/he already has. These data and skills cannot be anything but the construction of concepts and systematizations that the child brings from previous experiences. It's important never to forget that children, in general, are not repositories of adults' "knowledge", but human beings that are constantly trying to bring meaning, to understand their experience (Cobb, 1983).

What makes the environment propitious to learning is not just to talk about some intriguing phenomenon, but the mutual involvement in the act of discovery of a fact that puzzles by exploring different perspectives, linked to each other. Playing is as important as talking. When programming the clinical interview, the researcher designs a scenario, a game of some kind, which is at the same time intriguing and meaningful to the child. By "game", it is understood that it can be a language game or a design concept game (Habraken, 1993). It can take the form of a puzzle, a mechanical gadget or a computer-based personal learning environment. Once the approach is set, the interviewer "guides the child with the task of the proposition, while at the same time being guided by the child's own approach" (Piaget, 1963, p. 1-23).

The clinical interview should be conducted as well from both the adult and the child, and must bring new opportunities for exploration and learning as a result of interviewer-interviewee interaction. For the children, it is interesting to have on your side someone genuinely interested in their ideas, and going on to explore the full phenomenon, to share what they do and think. The hypothesis thinking and solution must be proposed by both

researcher and child, considering different points of views, changing reports, and frequently exchanging roles. The learning takes place from the moment that a space is open to explore and express ideas through different ways for different purposes, from different points of view.

The clinical interview can be conceived as an exploration of the interaction between what a person knows and how he or she uses this knowledge (Ginsburg, 1997), standing in the cognition area. This interview technique is widely used in developmental psychology, often with children. The clinical interview can be very informal because it takes its direction from the child's answers, based on what makes sense for him/her, that is the cognitive domain. There are also quite structured clinical interviews, with a predetermined number of tasks, questions and tests that are applied in a standard way in the child, but in this case we will adopt the first line, because in contrast to the open script interview, the explanations in the second approach are not normally considered a critical part of the data collected. Our goal is to get the explanations from the students about their thoughts at the time they were researching with digital devices.

The open interview is guided by theoretical constructions, although these mental edifices may appear and conceptions that support the theoretical framework. One way to frame this distinction lies in the contrast between the inductive and deductive approaches to building and analysing an interview. In the inductive approach, the researcher tries to describe the categories that emerge from the data during the analytical process. In the deductive approach, the researcher brings theoretical constructs for the research project; these questions are framed with the subjects and the analysis can be done by examining how the informants addresses these constructions during the interview (Lakatos, 1988). It is in this perspective that the interviews will be built.

A second feature that affects a clinical interview is to determine the strength of conviction behind what the interviewee says. As Ginsburg (2000) argues, Piaget noted that children tend to say what they believe the adult wants to hear, so he used methods of "repetition" and "counter-suggestion" for "insights" on the strength of conviction. Therefore, phrases like: "There is no right or wrong answer"; "I want to know what's going on inside your head, now" are repeated throughout the interview. When the interviewee gives a successful explanation, the same question is asked in a different way, with the suggestion to seek persistence in the responses. If a student seems to be reluctant, he is encouraged to say what comes into mind. These skills are especially important because of Piaget's discovery that

people have many knowledge structures and reasoning processes that are not the same and have misconceptions using non-formal reasoning in the learning process, often using prior knowledge.

Mapping this "hidden world" of thought is the main task to the success of instructional design. Students cannot fail to use their own previous ideas and thought processes during instruction, and these views have strong effects on the course of instruction. Since the tests are almost always written from the academic point of view and are designed to detect standard forms of academic knowledge, they may fail to detect key elements in the student's thinking. Clinical interviews, in the other hand, can be designed to obtain and compile the ways of thinking which are inherent to those subjects. Even when academic knowledge detection is searched, the clinical interview can give more information about the depth of conceptual understanding and may be collected and clarified where appropriate. However, the analysis of the interviews can be difficult and time consuming, always involving a deep interpretation by the researcher.

The choice of the clinical interview for the perception of critical thinking from students was due to the excellence of the method in preserving the integrity of the subject's thoughts and flexibility in the proposal of the questions offered to the student. The difficulty of creating a data collection instrument which could efficiently aim critical thinking of students, was solved in the technique developed by Piaget and it was possible to reach participants' cognitive area for this research[3].

3.2.3 Clinical Interview Adapted for Digital Devices

The student's web search histories were tracked and collected through the web browser installed on the mobile devices or computers, after completing the research protocol activity. In order to preserve the links to visited pages during the proposed activity undertaken by the students at school, each student's "Browsing History" was recovered, saved in the "Favourites Menu", and exported as HTML file. This approach met a primary goal of the

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[3] For Researchers in Brazil, is mandatory to do a six-months course of Research Techniques and Approaches, provided the University. After this training, the Researchers can have more confidence in their choices for the best approach on their Research. After being questioned where the Researcher has been trained to do such Clinical Interview, it was considered it would be better make a note for it.

research to minimise the researcher's interference in students' web searches, and avoid any situations that might inhibit the student's initiatives during activities and before videographies or recordings.

Once the web-histories of students' searches and activities was recovered, each student was invited to attend a clinical interview to explain their thoughts whilst retracing their search paths based on their saved web histories. The usual questions were, for example:

- "Why did you decide this result is more accurate than the previous one?"
- "Why did you decide to search on this website?"
- "What were you thinking when you decided this?"
- "Why did you decide to stop searching at this moment?"

The interviews with the students were audio recorded and their devices connected to the Internet, in order to revisit the same sites they had visited previously (as saved in the browser histories). As the students explained their steps they were asked about their own perceptions and analysis of decisions they had taken while searching the web, in response to questions or activities posed by the teacher. As the students justified their thought steps, it was possible to direct the interviewer's questions such that they could gain an understanding of the extent of which searches on web had become an opportunity for the students to display or develop critical thinking skills.

3.3 Data analysis tools

3.3.1 The Content analysis

Content analysis is used to document and understand communication and meanings, and to verify links within the research field and its theoretical framework. Its distinctive feature is the reflective and highly interactive nature of the investigator, the concepts, data collection and analysis.

The contents of a general analysis are reflexive movements between a concept development, sampling, data collection, data coding, data analysis and interpretation. The aim is to be systematic and analytical, but not rigid and inflexible. Although categories and

"variables" initially orient the study, other categories not provided may arise in the work of collection. Thus, the analysis is incorporated on discovery and constant comparison of relevant situations, settings, styles, images, meanings and nuances (Glaser and Strauss, 1967). Finally, content analysis is based upon the collected subjective and objective data, rather than forcing the latter into predefined categories.

According to Moraes (1999),

> As research method, content analysis includes special procedures for processing scientific data. It is a tool, a practical guide for action, always renewed in the light of increasingly diverse problems that proposes to investigate. One can regard it as a single instrument, but marked by a wide variety of forms and adaptable to a very wide field of application, which is communication.

Thus, content analysis, for its flexibility and comprehensiveness, is the most appropriate analytical tool for our study. It is essential in order to understand the subject and its peculiarities in the construction of critical thinking, which seeks to analyse the flexibility of an analytical tool. In the case of our research, there were many subsequent issues, from the execution of the preliminary study.

The steps provided by Ferreira (2003) for content analysis can be summarized in three phases: 1. Pre-analysis; 2. Exploration of the material; 3. Treatment of results. In addition to these steps already listed by Bardin, Moraes brings in a more didactic approach to the description of content analysis steps, which is the actual reporting of results, reporting clearly the results of the work. Interpretation, where the analyst notes that "content analysis interpretation is not only about manifest content by subjects, as well as on the latent ones, are they hidden consciously or unconsciously by the subjects" (Moraes, 1999, p.09).

Data analysis aims to understand if, through research movement with digital devices in the school, critical evidence and / or critical thinking skills would arise from students, and for this the interviews will be analysed from the preliminary study and the main study, in which the clinical interview will be used.

As our aim is to analyse critical thinking and propose a theory about knowledge. Content analysis provides an opportunity to evaluate perception of critical thinking in various levels, including observing variations of the same representation in the category. On the other hand, it is necessary to analyse not only the expressed content itself, but also the latent content, ie those that are not expressed clearly but are implicit in the contexts. Content

analysis aims to enable this perception when Bardin (2009) defines it:

> It is a set of communications analysis techniques to obtain, procedures, systematic and Description of the objectives of message content, indicators (quantitative or not) that allow the inference of knowledge concerning the conditions of production / reception (inferred variables) of these messages (Bardin, 2009, p. 42).

We divide the task up, then use the software support, and provide the content analysis according to the procedure laid down in stages by Moraes (1999), namely:

1. Preparation of the information, by reading the materials collected and transcribed and made the selection of those who really would be relevant to our research proposal. This step was also made the codification of information, where each document received the code to facilitate its location in the software later.

2. Unitarization: the units of analysis. Here, is preferable to see the unit as all the interviews collected in the clinical interview, the relevance of his material, opting to make the observations and other studies material for consultation and support.

3. Categorization. According to Moraes (1999), "the categorization is a procedure to group data considering the existing common part between them." Thus, the categories of analysis are defined according to the lexicons criteria, "with emphasis on the words and their meanings" (1999, p.56).

4. Description. Here, it is possible to describe the categories which were found, basically communicating the result of the investigation. Here, the theoretical foundation serves as ballast for our discussion.

5. Interpretation. The interpretation work deals with all that has been built and brought from the proposed study. At this stage, the researcher works with their own conclusions and referrals.

After these steps, it will be possible to validate a theory that can explain the method of critical thinking operating with digital technologies in human beings.

3.4 Ethical Considerations

All the information collected has been saved electronically and kept safe. It is not the intention to share children's particular data with people who are not members of this research group. It was an agreement between school and researchers and this confidentiality was considered to be one of the key ethical considerations for the study.

The Information collected throughout the research was held in confidence and stored securely in a locked filing cabinet or on a password protected computer. There is no identification of participants included in the final thesis, or lost and damaged, also the commitment extends to any future publications. The names of institutions have also been preserved.

Two phases of data collection happened: the first, while children performed research activity protocol on internet and had their search web history recorded. These web histories were analysed and the clinical interview took place two days later. The interviews were performed inside the school, in a private room with computer and internet. They have been audio recorded and saved in electronic formats immediately, to avoid damage or loss.

The methodological steps of the study previewed the transcriptions of interviews and analysis, which was done in the United Kingdom. All data collected was used.

All documentation was provided to participants, their parents and the school. The research information sheet and consent form (appendix) included information which was recognised to be necessary to secure full informed consent. The local law, in Brazil, requires the school and researchers to follow the Child and Adolescent Statute's rules. The researcher and the head teacher personally checked that health, safety and privacy rules were followed.

3.5 Limitations of Study

The limitations of this study need to be considered alongside to the methodological approach. The transparency of this research brings reliability for the process. The population

in which this study has been developed has a different cultural background if compared to European nations. This must be considered while making other data collections using the same method: depending on the population, the data collection can last longer or go faster. The researcher must know really well the population to be studied, to develop a good research protocol activity.

The first ten questionnaires answered completely online, without the approach for a Clinical Interview, have not reached the cognitive area of children. The interaction with the clinical interview proved to be the best approach because children asked when they did not understand a question, so that the researcher could follow up an obscure point of children's answer.

The students who participated in this study received special attention so they did not get tired quickly. However, a couple of them asked for a break while researching on the web. One girl asked why it was necessary that for her to be recorded. It was explained to her that it was to make it easier to take notes later, which apparently made her feel comfortable. While dealing with children, even with parents and school consents, it is necessary to be honest and help them trust the researcher. If dealing with young adults the results could have been collected more quickly.

3.6 Summary

This study aimed to present the main research data instruments and collection analysis. Case study as a research modality, however, its importance as an instrument is undeniable. The data collections tools have been a research activity protocol, which aimed to collect all relevant aspects of data needed. The Clinical Interview developed by Piaget (1975) was adapted for digital devices, being performed after the research protocol activity. The data analysis instrument was the content analysis, which was focused on quality data analysis. The software Atlas Ti 8.0 helped to organized all data from content analysis to systematize all work done.

The data collection was done in two parts: Pilot Study (2011) and Main Study (2016). The populations were different, but the research techniques were the same. The study performed on 2011 for its characteristics, was an Exploratory Study which led to the Main study in 2016, this time an Explanatory Research.

Chapter 4
Participants, Results and discussion

Chapter 4: Participants, Results and discussion

      This chapter describes the participants and schools from both studies, and discusses the results and findings on them. Although both studies had the same methodological design, the Pilot Study pointed to a broader comprehension of the Critical Thinking phenomenon. The Critical Thinking Categories were presented in the main study (Interpretation, Analysis, Inference, evaluation, explanation and self-regulation) other categories emerged strongly, which allowed the researcher to think about another possible categorization.

After the mobilization of several of these cognitive skills, and investigative movement, it was possible to observe three levels of judgment: the "reflective judgment", the "critical judgment" and "deliberate judgment" (Facione, 2014), as the author stated. The other *emergent categories[4]* had not fitted into any of those levels of judgement, for one reason: they were not related to the cognitive behaviour, but they were decisive conditions that affect the results.

      While analysing the Pilot Study results (Valle & Abranches, 2011), the researchers involved in this study were led to look for other explanations for the phenomenon involving the critical thinking behaviour, so the best approach was found in Cybernetics, that clearly explained the phenomena. In 2016, the Main Study data collection was adjusted and repeated, now looking at Critical Thinking through the Cybernetics lens. This experience allowed us to build a cybernetic model of Critical Thinking.

4.1 The participants

      This section aims to describe the participants from Pilot and Main studies, their school system and environment. This approach will bring a better picture of what elements could possibly interfere in these participants' performance during the study.

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[4] Emergent Categories, or Categories *"A Posteriori"* are defined as "all categories that arose during the data analysis, not previously defined or predicted from researchers (Lakatos, 1988).

4.1.1. The Pilot Study

The researcher developed the observations and performed data collection in a school in the state of Pernambuco, in the northeast of Brazil, in 2011. The work as a researcher during the implementation of the UCA (Um Computador por Aluno/One Laptop per Child) Project, facilitated the observations and allowed these to be frequent. The school operates in three shifts, and the day shifts for Elementary Studies for children (ages 7-14 years old). In Brazil, children have only four hours daily at school. Over almost two years, this research was developed observing children, dealing with questionnaires, and, finally, the clinical interview. The school from which data was collected was randomly selected and it has 62 staff members (including teachers) and 578 students. Two classroom were chosen to build the data *corpus:* the fourth and fifth years of Fundamental Studies, as found in next table:

YEAR	NUMBER OF STUDENTS	AGES
4TH	23	9 – 11 years old
5TH	19	10 – 12 years old
TOTAL	42	-

Table 4.1: Pilot Study participants in Year Groups

The research`s subjects, 42 students from the Brazilian One Laptop Per Child program, aged between 10 and 12 years old, were observed dealing with OLPC`s notebook for almost 2 years. Semi-structured interviews also supported the research. However, during the gathering it was decided to conduct the clinical interview with the children, as the instrument most appropriate data collection to the purpose: to comprehend the development of students' critical thinking while using laptops (Valle, 2011).

4.1.2. The Main Study

The main study was performed in a school in the northeast of Brazil. In the State of Pernambuco, in the metropolitan region of Recife, a school named Vereador Antonio Januário was chosen. The school is located in a poor region, known for the lack of resources and quality of life of its inhabitants.

The school works in three shifts (3 groups of students for 4 hours classes, each). Due to great demand, schools in Brazil have 4 hours classes for each student, and works in three shifts: morning, afternoon and evening. The data collection was performed in the afternoon shift (from 13:30h to 17:30h), for two weeks.

Year	Number of students	Ages	Type of collection
7th	18	12 – 13 years old	Clinical Interview
8th	14	14 – 15 years old	Online questionaires
Total	32	-	-

Table 4.2: Main Study participants in Year Groups

The educational structure in Brazil is different, with different year groups. So, the data collection was performed with students from Year 7, aged between 12 to 13 years old, and Year 8, with students aged between 14 to 15 years old.

Once a week, students take classes in the computer lab to perform an activity proposed by one of the teachers who take turns for the use of the laboratory. Students, however, have access to the Internet in their homes, and in public accessible places during the period they are not at school.

4.2. The Pilot Study development

The challenge of creating a collection strategy that did emerge from the objectified data was overcome using the clinical interview strategy. This chapter describes the creation and collection of data about critical thinking. The study was intended to capture critical thinking - or its evidence - as the a priori categories previously defined. Thus, the collection strategy was designed so that students could freely expose and explain their thinking on the research. This section is dedicated to describe this study.

The clinical interview is a pioneer research technique developed by Piaget (1975) to study the form of knowledge structures and thinking processes. If properly conducted, it can be conceived as an exploration of the interaction between what a person knows and how he or she uses this knowledge, based in the thought`s conception area.

For this, an appointment was set using the Internet browser search history itself that is placed on each student's computer. Minimizing some researcher`s interferences in student`s web search, avoiding some situations which would inhibit the children`s initiatives before possible videographies or recordings, giving us a mistaken feedback, was the great goal of this research technique. Thus, the first step was to recover the web-history of previous studies and activities by the students with the teacher in the classroom.

The history browsing data from each student were collected and preserved as HTML document. Free internet browser used in OLPC project is Mozilla Firefox. The "Browsing History" was recovered and saved in the "Favourites menu", exporting as HTML. Thereby links of the visited pages were preserved.

The next step was to ask each student to attend an interview to explain their thoughts while retracing their steps on previous searching. This meeting was video recorded and computer-connected to the Internet, seeking to revisit the same sites (which were saved in history) while requesting information about their own perceptions in its analysis of search results on the Internet, pointing student`s decisions during web search. As the students justified their thoughts` steps within the research proposed by the teacher, it was possible to redirect the interview`s questions to understand how far the search with the laptops was an opportunity to the critical thinking skills` manifestation by students.

From previous studies (Valle, 2011), the categories of critical thinking can be defined as result of the analysis of movement that the research participants did to evaluate the arguments. These categories are described by Facione as:

> The cognitive skills of analysis, interpretation, inference, explanation, evaluation, monitoring and correct the own reasoning are at the heart of critical thinking. Through practice, and with good guidance, we can develop our thinking skills (such as our artistic skills, athletic or leadership), the extent of our natural abilities allow. Critical thinking is the judgment, reflective and intentional. (FACIONE, 2014, p. 04).

According to Facione, critical thinking skills should be listed in ascending order. When a person comes to a more complex critical thinking level, it will be possible to use more of the following provisions. Previously, the categories might be considered as process variables, but on closer examination, Cybernetics principles can be applied to define and understand them, as explained. In a previous study (Valle, 2011), the categories were listed as described by

Facione, who classified the emerging situations of a system as variables, then concluding the research. In this study, by applying the principles of cybernetics to analyse the situation regarding Critical Thinking in schools, we were able to evaluate the wider questions concerning critical thinking and propose a new classification.

4.2.1 Results of the Pilot Study

From those studies, emerged the following categories, selected previously from Facione`s classification*:* 1 - the Elementary Level (Interpretation an Analysis categories); 2 - Second Level (Evaluation and Inference categories); 3 – Explanation , demonstrating a deep level of critical thinking and the last one, 4 - Self Regulation, which can represent the stronger critical thinkers.

However, two unexpected categories emerged during data collection as highly relevant: the categories named by us as "Breaking Up" and "Fear". Both categories decisively influenced the ability of the students to think critically, interfering directly in the formation of their criticality to the point of making them redirect their thinking or give up their line of reasoning undertaken to date in research. "Fear" is a decisive element, which refers to the fears and uncertainties expressed in the clinical interview by a fear of displeasing or incurring "error" (Valle & Abranches, 2011, p.84). "Breaking up" brings us some elements in the opposite direction: despite all the dynamics surrounding the classroom practices, there was some movement from subjects towards breaking the original program proposed by the teacher. This movement sometimes was made to deepen and complement their knowledge and sometimes there was a complete break in the search, looking for other subjects of their interest, like football, games and celebrities news.

In this case, 75% of subjects can be described within the "Breaking Up" category. It leads us to understand how representative and important can be this conflict for students. The motivations that made those children standing passive without moving on breaking up with the teacher`s plan can be represented by the fear linked to anxiety and fear to think differently. The fear in this situation was decisive to children who considered whether to move forward or not. It was a situation which led us to the next category: Breaking up.

"Breaking up" means the children are not exactly doing the same activity as planned from the teachers. They have chosen to abandon the paths proposed by teacher and make their own way, including some elements that were absent or not foreseeable from the teacher. According to some children`s descriptions, the motivations to break up were varied: disapproving of the teacher`s original plan, the wish to learn more about the topic (moving beyond with their search) or the wish to complement their search.

As stated previously, the results above were collected from the Pilot study during implementation of One Laptop per Child project (Valle & Abranches, 2011). It is important to note the results identified two extra categories beyond Facione's critical thinking classification. If looked at closely, the categories may point to the elements of a Cybernetics system, with the feedback movement to consider. This hypothesis was explored on the following data collection, namely the main study.

From the first moments of the data analysis, was possible observe that some participants were embarrassed and left for two different kinds of reaction: they faced the disturbance, no matter what the reason; or they finished the nuisance and discomfort caused by the situation, ending the search exactly as they had been asked to do. An undeniable disturbance caused these two phenomena to occur, directly interfering with the results of the research. For this reason, it was decided not to ignore it but to classify the two occurrences of the same phenomenon as another category.

However, if we look closely, the categories do not refer to data of human cognition itself, but to external influences in the open system: the brain. In Content Analysis, are not possible to categorize two different elements, from distinct origins and nature, in a same group. The "unitization of the units of analysis" is the second step of Content Analysis, and would not allow these two external elements ("Fear" and "breaking up") to remain within the cognitive categories. Because of the lack of a multidisciplinary approach, the categories have been named, anyway, but new studies emerged with this approach.

Those two categories are too large to ignore: they were present in every data collection. Although they are not properly cognitive elements, this research aimed to find an answer for the phenomena.

4.3. The main Study

The school provided a room used as a computer lab for student activities during school hours. Because the IP address is the same on each computer, the "Survey Monkey" tool only allowed the completion of one online data collection questionnaire per day. The option was then made to use the computers for the online activity and answer the same questions of the questionnaire in an interview, which was later transformed into a clinical interview.

Thus, we had two groups of data collection: the first, with 14 students, performed the activity completely online, reading and answering the questionnaires. The second group, with 18 students, performed the activities on the school computers and answered the interview questions following the methodology of the clinical interview proposed in the previous chapter. The research activities were done on the web before the snack time and the clinical interview soon after the retrieval of the search history on the web.

It is important to emphasize the use of the Web, in school, as a pedagogical tool. Despite the difficulties encountered by teachers and students while they take turns in the computer lab space and the lack of support from the City Hall, a contextualized web work is done at the school. Students, in general, had no difficulty completing the task proposed during the research.

4.3.1 The initial analysis

The vision of modernity certainly comes together with technologies used in the digital age. Feeling included is very important for students and makes them feel part of society, prestigious, rich. Although this view is rather naive, as is seen in Cazeloto (2007, p. 97), because digital inclusion would be "an artificial creation of social engineering, created to extend to the greatest possible number of citizens the possible benefits that an elite already enjoys fully, as a 'natural' part of their insertion into society. "

Technology reflects the way specific societies organize the relationship between available pragmatic (technical) knowledge, values, interests, and the physical environment. This implies that, according to the understanding presented in this work, the notion of

technology already has in itself a strongly social component. The human relationships define a more or less positive or conscious content of what they wish to transform. It is possible to say, then, that technologies are the ways knowledge is socially articulated for valid interests.

The web search is greatly explored by school teachers. In the students' speech it is easy to perceive a good handling and a facility in the treatment of the internet access in the school. All students knew how to search the portals, by accessing the web search without any guidance and moving forward. They demonstrated knowledge about the purpose of a blog, a video blog, how they work, simple video and image editing.

After the simple completion of the questionnaires by the students, it was observed this would not be satisfactory to reach the Cognitive area of participant's brains, using this kind of data collection instrument. Often, participants misunderstood the questions and lacked the explanation of the reasoning itself in developing the activities. In addition, it was not possible to reach the students' cognition area; the collected data became superficial, although some of the critical thinking skills were present. Once more, the Clinical Interview was the best option to reach the cognitive function of students.

4.3.2 The Clinical Interview: description

The Clinical Interview was adapted using the search history of the internet browser that is stored on each student's computer. An effort was made to bring a result as free as possible from environmental or teacher's influence. Students should feel free to develop the research protocol as they wish. For this, the first step was to recover the web search history of already carried out by the students with the researcher, doing the same research protocol proposed as an online activity, plus questionnaire.

With this data, each student was asked to meet privately with the researcher in order to follow the same paths that they had previously traced in their web search. This conversation was in front of a computer connected to the Internet, seeking to revisit the same sites (which were saved in history) and requesting information about their own perceptions in their analysis of Internet search results. To the extent that students justified their thoughts or research choices within the research protocol proposed by the researcher, it was possible

to address the questions in order to see if critical thinking skills had been mobilized, where such skills were inherent.

4.3.3 The Data Collection

The clinical interview was conducted with 32 students of the school, privately, that is, without the supervision of the teacher, in October 2016. No observation was made of the school routine and the interaction between teachers and students. The researcher entered the school, proposed a web activity protocol for the participants, followed the clinical interview and left the school after the collection. This was done during a two week period.

The research was carried out on the premises of the participating school, in rooms reserved for the interviews, in which the interviewer and the participant remained, in an environment reasonably free of interferences that could bring bad results for the progress of the research. Interviews were only conducted after parental consent, in accordance with ethical research procedures. All the procedures performed followed the rules established by the Statute of the Child and the Adolescent (ECA - Law 8.069, of 07/13/1990), Brazilian law that regulates actions involving children in all Brazilian Territory.

On request and while viewing their research trajectory on the computer, the students described the reasons for their redirection of research, their analysis, and the mobilization of the necessary skills for their inferences. Everything was recorded in digital audio and transcribed in order to facilitate the analysis of content itself.

As a central theme, the choice was the book series Percy Jackson (Riordan, 2013), a fiction involving Greek mythology, becoming a world-wide success by recounting the stories of demigod adolescents adapted to the research on the Web. They live their adventures while attending secondary school. In this collection, the activity protocol followed a research model with videos and script that led them to investigate the history of the Minotaur.

The interview was conducted based on the research protocol, search activity and redetermination of the knowledge elaborated by the researcher, and composed of questions that aimed to trigger argumentative answers related to the specific objectives of the research. Generally speaking, the questions referred to the understanding of the myth itself, or to the comprehension beyond the elementary judgment, seeking to recover the critical thinking

abilities mobilized while carrying out the activity. Thirty-two participants completed the online research protocol, which consisted in searching about the Minotaur myth. To make sure that the participants had understood the main aspects of the story, the first question of both types of collection was to retell the myth. After this, the participants answered questions related to the research they had done on the web, with an emphasis on understanding the criteria for selection and critique of the information found. The interviews were recorded for later transcription and analysis.

4.3.4 The Activity

Children were asked to complete an activity online, after that, to answer a questionnaire with open questions.

Web address: http://criticalthinkingresearch.weebly.com/

Figure 4.1: Web page created for data collection

Translation: "Hello! How are you? We are participating in a survey and we need your help. In this case, just complete a few steps in the proposed activity and answer some questions. Well, the first step is to watch the video below" (2min37sec movie trailer):
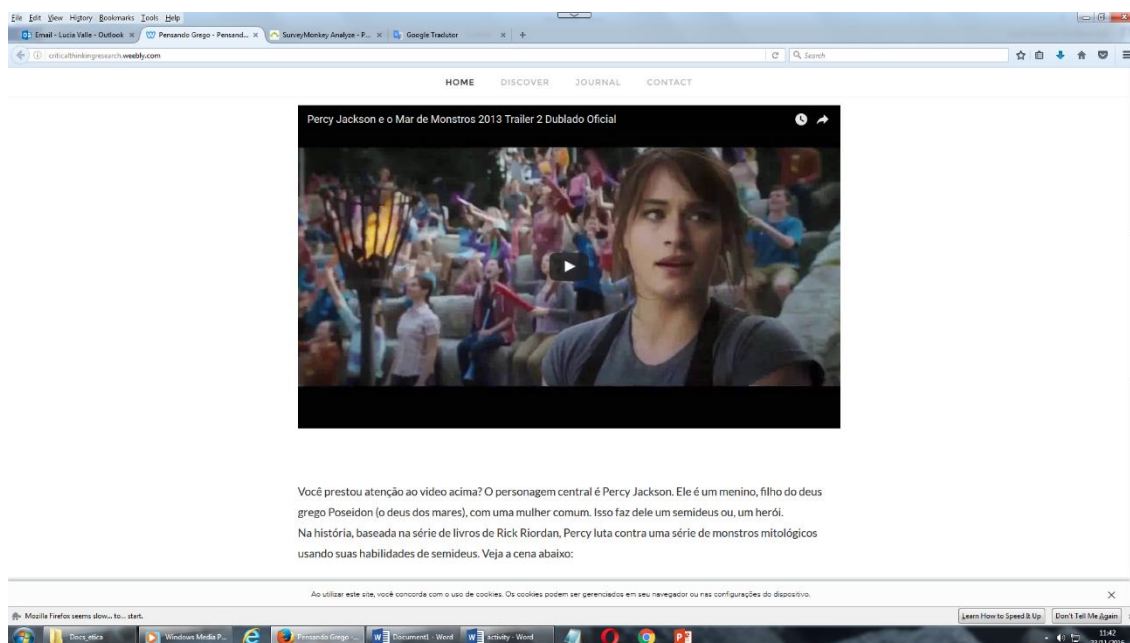
Figure 4.2: Web page created for data collection

Translation: "Did you watch the video above? The central character is Percy Jackson. He is a boy, son of the Greek god Poseidon (the god of the seas), with an ordinary woman. That makes him a demigod or, a hero.

In the story, based on the Rick Riordan book series, Percy fights against many mythological monsters using his demigod skills. See the scene below" (another 2min43sec video is showed):
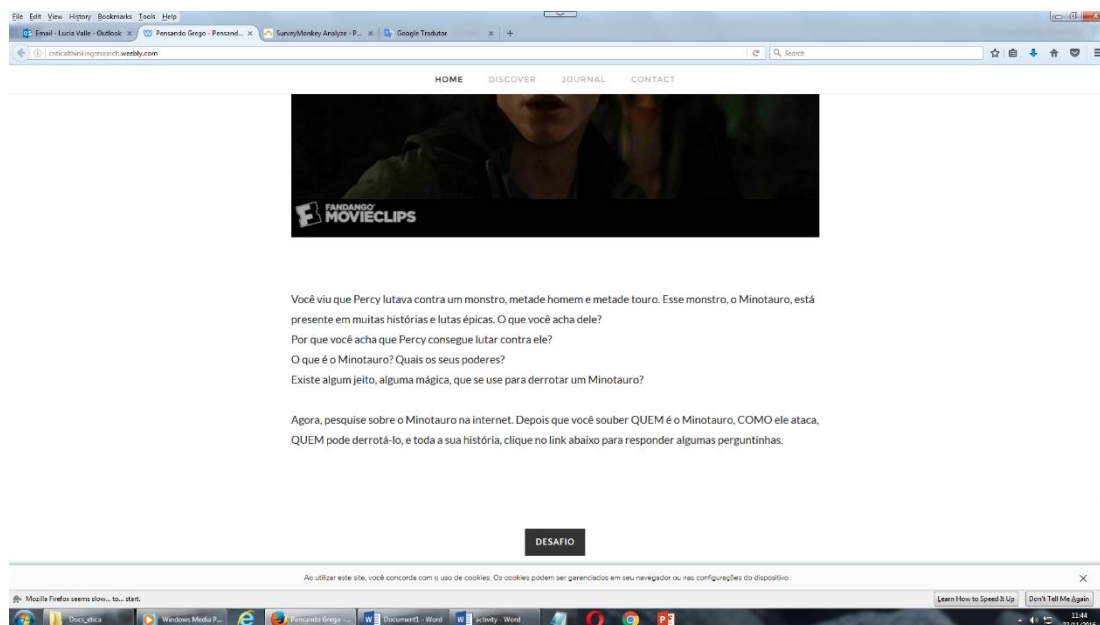
Figure 4.3: End of activity protocol

Translation: "You saw Percy fighting a monster, half man and half bull. This monster, the Minotaur, is present in many epic stories and struggles. What do you think about him?

Why do you think Percy can fight him?

What is Minotaur? What are his powers?"

Is there any way, or some magic, to use to defeat a Minotaur?

Now, research about the Minotaur on the internet. Once you know who the Minotaur is, HOW he attacks, WHO can defeat him, and all his story, click the link below to answer some questions."

The link would redirect the children for the Survey Monkey platform. They should answer the following questions: (web address: https://www.surveymonkey.co.uk/r/VPTRLSX)

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1. Please write your name, the name of your school and your age.

2. Briefly summarize, with your words, the story of the Minotaur.

3. What did you like the most in the story of the Minotaur? Why?

4. Did you find the information easily? How come?

5. When you searched the information on the internet, how did you decide which were the most important?

6. Do you think the information you have found is reliable? Why?

7. Is there a relation between the myth of the Minotaur and other Greek myths? If so, which ones?

8. What events do you consider essential for the myth of the Minotaur to have this end?

9. If the myth of the Minotaur is re-created today, what do you think would happen?

10. You certainly had heard about the Minotaur. What did you find in the survey was according to what you already knew? Why?

4.4 Data Analysis Instruments

As previously mentioned, the data analysis instrument chosen was the content analysis technique, since it was the qualitative data analysis technique itself, taking full advantage of the clinical interview. For this second step, it was possible to use the data analysis software known as ATLAS Ti, version 8.0. The software allows the categorization provided by content analysis, the organization of data and the opening of webs to understand the result.

In this sense, the subjects' speeches were followed to reach the level of criticality - even if incipient - of the students in the school. We present the analysis and discussion of the collected data and the categorization webs in order to facilitate the subjects' visualization and *a priori* categories, followed by any other elements that emerged during the interview.

The categories used in the analysis of the Atlas Ti for critical thinking were those already mentioned: analysis, interpretation, inference, explanation, evaluation, ability to correct one's logic. Two categories of a different nature, external to thought, emerged quite forcefully in the students' report in the pilot study and were preserved: the category of "fear" and the category "breaking up".

These categories emerged in the main study, again, and were renamed, through an understanding of the studied cybernetic phenomenon, happening to be called "Deterrence" and "Breaking Up", both treated as a result from Entropy, a new category that emerged as a disruption of the system. When a Cybernetics model for critical thinking is being built, it is possible to perceive emerging categories as categories not of critical thinking, but categories related to search dynamics and search movement, systemic, because they connect more with the cybernetic phenomenon than with cognitive abilities of critical thinking.

	Name ▲	Grounded	Density	Groups
● ◇	Analysis		29	0	[Inicial Judgement]
● ◇	Breaking Up		22	0	[Cybernetics Elements]
● ◇	Deterrence		30	0	[Cybernetics Elements]
● ◇	Elementary level		10	0	
● ◇	Entropy		40	0	[Cybernetics Elements]
● ◇	Evaluation		43	0	[Inicial Judgement]
● ◇	Explanation		54	0	[Deep Level]
● ◇	Inference		75	0	[Intermediary Level]
● ◇	Interpretation		34	0	[Inicial Judgement]
○ ◇	Irrelevance		12	0	
● ◇	Self regulation		17	0	[Deep Level]

Figure 4.4: Categories of Critical Thinking

The image shows the categories listed from Atlas Ti software, already explored and defined in previous chapters.

4.4.1 Atlas Ti software

ATLAS Ti is a computer program developed by the University of Berlin, Germany. It aims to offer textual interpretation support, being developed in the context of an interdisciplinary research project called ATLAS (Translated as Archive for Language in Technology, World of Life and Daily Life) and Ti (textual interpretation). ATLAS Ti was designed for use in qualitative social and linguistic research as a support oriented to researchers involving text interpretation. This includes the ability to handle large amounts of text also working as the manager for annotations, concepts and complex structures between conceptual relations that emerge in the process of interpretation, leaving the creative and intellectual tasks with the researcher.

The Atlas Ti software helps to discover complex phenomena, which could not be detected in a simple reading of the text, especially in relation to the traditional technique of data processing manually, because it is possible to integrate hermeneutical units (primary projects) with each other. It is important to stress there is no software to perform the entire independent analysis procedure of the researcher. It is necessary, therefore, that the researcher knows the potential and the limitations of the software to adapt it to the base theory used for analysis. Our study focused on the context, the processes and the subjectivity in which the subjects are involved.

With the Atlas Ti software was possible to organize different documents or data collection instruments, like answers to open questionnaire questions, observation reports, any kind of text expressed in written mode, as well as audio (transcription of interviews, songs, meetings, lectures), images (photos, drawings, paintings) and videos (recordings of television reports, classes and films). This software is ideal for working with large amounts of textual data, organized in different formats. In addition, Atlas Ti allows you to encode and analyse other types of image, video, audio formats displayed or not on websites provided in HTML.

The main *corpus* of a Qualitative Research in Atlas Ti software is named **Project**. All documents belonging to the data analysis are saved in the software with a Project name. The main elements connected to the Atlas Ti software and which are part of a **project** called **Hermeneutics Unit** are: the primary documents **(P-Docs)**, which in our case are transcribed clinical interviews and online questionnaires; the excerpts in each interview that correspond to the categories of analysis *a priori* **(Quotes)**, categories of analysis **(Codes)** and notes **(Memos)**. These elements give rise to webs (analysis tools that can be used to illustrate the relationships that were analysed by the researcher), as can be observed in Figure 4.5 in relation to the category of analysis "Self-regulation":
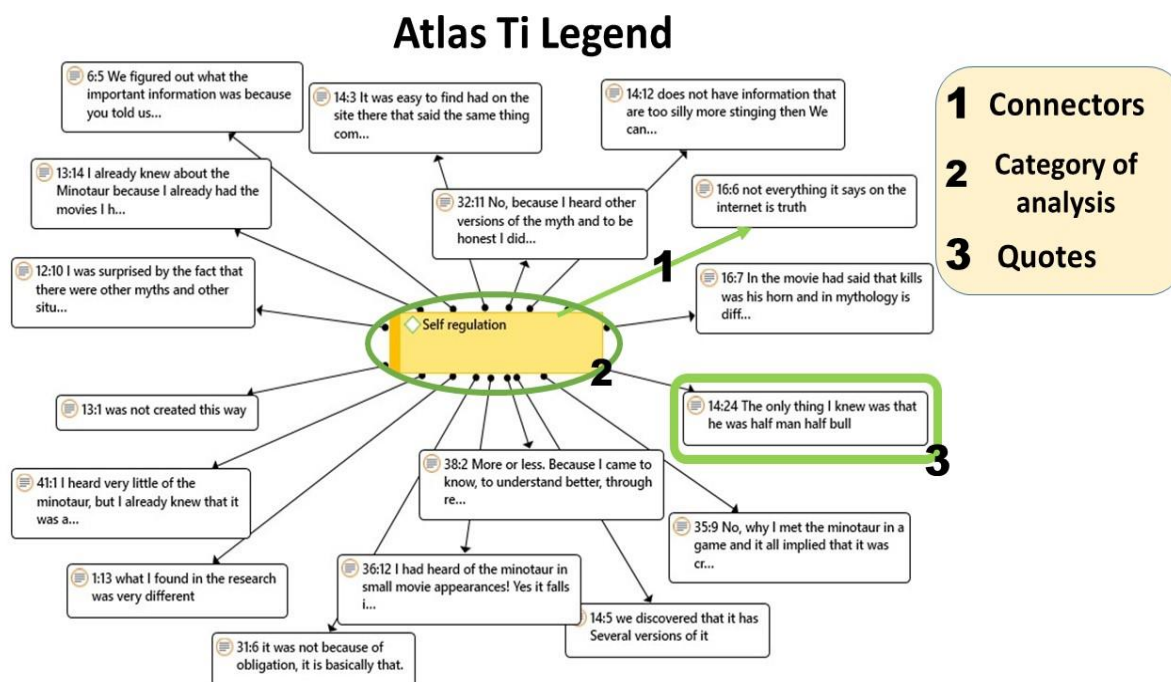
Figure 4.5: Atlas Ti Legend

On the figure 4.5 it is possible to see one of the webs, as a result of an entire process of data analysis in the corpus of the data collection. In the centre of the web, it is possible to see the category *a priori* named Self-Regulation (2). The category is linked by the connectors (1), expressing a causality relationship, to the quotes (3). The quotes are the excerpts from the interviews selected according to the categories definitions, during the data analysis period.

4.4.2 Description of Web browser search history (example)

In order to help the understanding of the collected data, we started the analysis by the search history of each student's Mozilla Firefox, except for the purpose of the clinical interview, when we asked which criteria the student had used to select the pages. In these histories, it is possible find the pages that are listed at the top are those that have been visited most recently. Therefore, if we want to observe the first pages the student visits, we will have to do it from the end of the list until its beginning, so the first of the list is the last web page the student visited.

A) D41-SMA10: Description of search history

The search history of this student, labelled as D41-SMA10, shows he started his research for sites already oriented during the protocol of activity. The student came to the orientations of the web page prepared for the research, following the search pages on the internet.
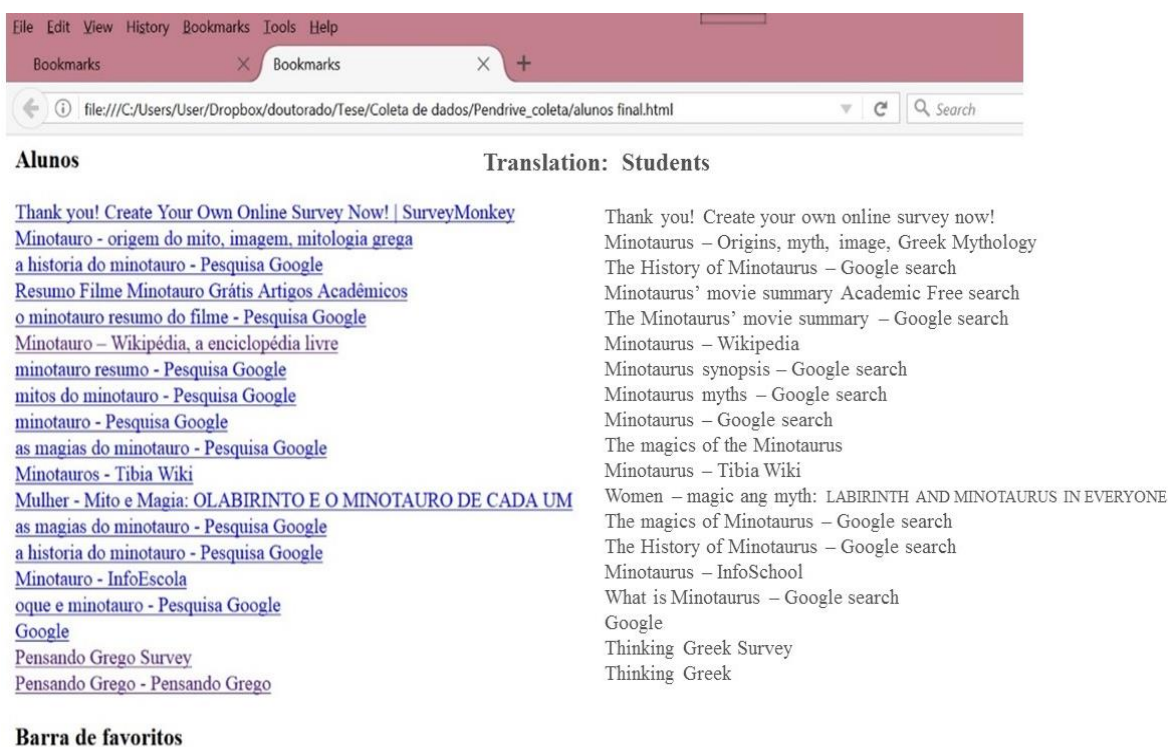

Figure 4.6: Web history of Participant D41-MA10

The participant started by the lower level: "What is the Minotaur," he asked Google. Examining the results, we see that he chose the InfoEscola web page, one of the first results. After reading the page information, he returned to the search tool and searched: "the story of the Minotaur". This time, he did not select any results, but left for another Google search: "The Minotaur's curse." Despite being a myth, the Minotaur is not a properly magical being and, given the limited number of results, he selected the page "Woman - myth and magic: the Labyrinth and the Minotaur of each one", which deals with the legend of the Minotaur but also brings aspects of the human *psyche* linked to myth. Then the participant goes from this page, without returning to the search portal, to another call Tibia Wiki, which deals with myths in the same Wikipedia format. Then he returns to the previous search: "The Minotaur's curse" and after that he decides to simply search "Minotaur" on Google. Without selecting

any result of this search, he searches again in Google for "Myths of the Minotaur" and, after that, for "Minotaur summary". In this search, he selects the Wikipedia result on the Minotaur. Still not satisfied, returns to Google search, to look for "Minotaur summary of the movie" by selecting among the results "Summary Minotaur Free Movie Academic Papers". Without interrupting the search movement that gives rise to critical thinking, he returns to Google Search and searches for "the minotaur story." Among the results, it selects "Minotaur - origin of the myth, image, and Greek mythology." The last visited site is the Search Protocol site of the beginning of the search.

At no point did the participant deviate from the proposed search protocol in order to research subjects of personal interest, social networks, games and the other subjects not linked with the research protocol. He selects popular search sites for information, even from questionable sources such as Wikipedia and InfoEscola. Through the student-search movement recorded in the browser, we were able to have greater accuracy with respect to the movement of such students while they were online. Thus, there was the opportunity to redo this same search movement a second time with the students, and question them about their thinking and motivations, the explanation of their presented abilities. As we can see, each subject traced his search path and, although the research trajectories of the students were sometimes similar, in essence each participant kept their own line of research development. What is important to realize before the search history is that some have used the moment of research to go deeper into the topic suggested in the protocol. Others simply fulfilled what was strictly necessary to dedicate themselves to other searches and in a third situation the participant did not even complete the requested search and remained quiet on the last page of the web visited. Does it show timidity, or a lack of interest? These questions were then answered through the clinical interview.

B) D37-CI10: Description of search history

Other example of a student with different search strategy can be observed in this web browser search history. This student is the typical example of how the clinical interview

can be useful for the purpose of our research. He starts from a very specific perspective, due to previous interactions with other colleagues, comes to general history of Minotaur, and gets back to the same specific pathway. It could be very confuse, but after the Clinical Interview it was possible observe what he was looking for.
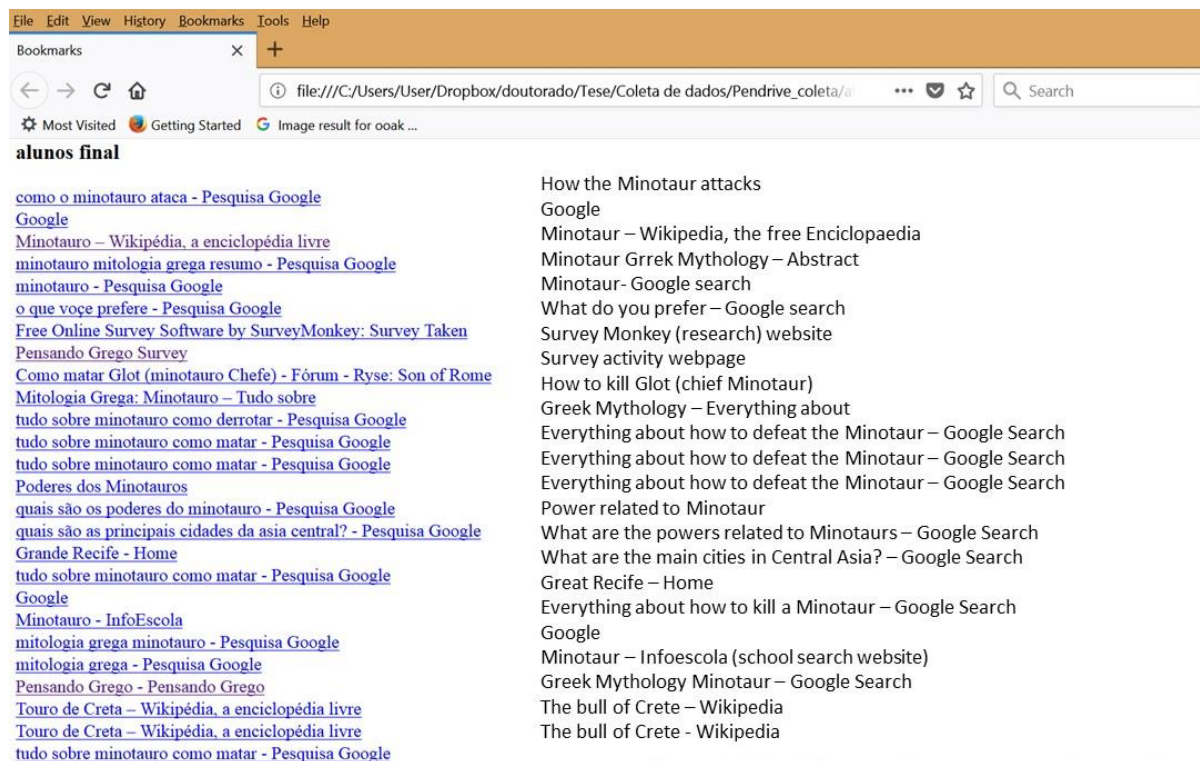
Figure 4.7: Web history of Participant D37-CI10

The participant started from a very specific point: How the Minotaur attacks. Google seemed not to give what he was looking for, so he came back for the same search, this time, going to Wikipedia webpage: "Minotaur". After this, he asks for a summary of Minotaur's story. He reads a page specialised in Greek Mythology and comes back to Google. "What do you prefer", apparently he types. After the Clinical Interview we found he just clicked in one advertisement by mistake.

Now, he visits for the first time the page where the activity protocol was proposed. He seems not so impressed, so he comes back to Google and asks "How to kill Glot", which has apparently nothing to do with the proposal of the research. During the Clinical Interview, he revealed he discussed with his colleagues and they decided the "big deal" would be killing the "chief" of Minotaurs. This question brought him to "Everything About Greek Mythology"

page, where he found there only existed one Minotaur (he corrected his thinking, mentally retracing a strategy to kill *the* Minotaur).

Back to the web, he traces another search: "everything about how to defeat the Minotaur". He searched for the results in three pages of Google Search, and went to check the "powers related to Minotaur". After that, he searches for "What are the main cities in central Asia?", after that, he searches for the "size" of his own city. It seemed he was deviating from the point of research, while he came back to Google and asked "Everything about how to kill the Minotaur", after that searching for "the Minotaur" and remaining in the InfoEscola (School Search Webpage) result for about four minutes. Back to Google, he asks "Greek Mythology Minotaur", to Google Search, and visits two results named "The Bull of Crete". This participant gave us a perspective that the movement of web search can bring someone to the better way while dealing with critical thinking. He tried to start from the end: "How to defeat a Minotaur?" and had to come, step by step, to the beginning: "Greek Mythology: The Bull of Crete." At the end of Clinical Interview, he concluded it was better know what "things means" first, or he would spend precious time.

4.4.3 Analysis of interviews

The preliminary study was very important in providing the best data collection and analysis methodology to be adopted throughout the research. Another situation that needs to be clear before data evaluation is that if an initial skill does not emerge during the interview clearly, but the subsequent ability is clear, this leads us to conclude that the participant cannot have mobilized Categories of deep critical thinking without previously mobilizing the other skills needed to reach the level shown. This may occur even if the participant does not manifest these initial skills. A person cannot show advanced critical thinking skills without keeping the initial ones in the background: it is like someone who knows how to run but cannot walk. It is not possible.

Another point of the second collection, made for the main study with 32 students, is that it validated the proposition of the theory raised for critical thinking with the help of Cybernetics Science, with only a few adjustments. It was possible to perceive clearly the

cybernetic movements of thought entropy and of deterrence or breaking up. Thus, we begin to explain the presentations of the categories of data analysis found during the collection.
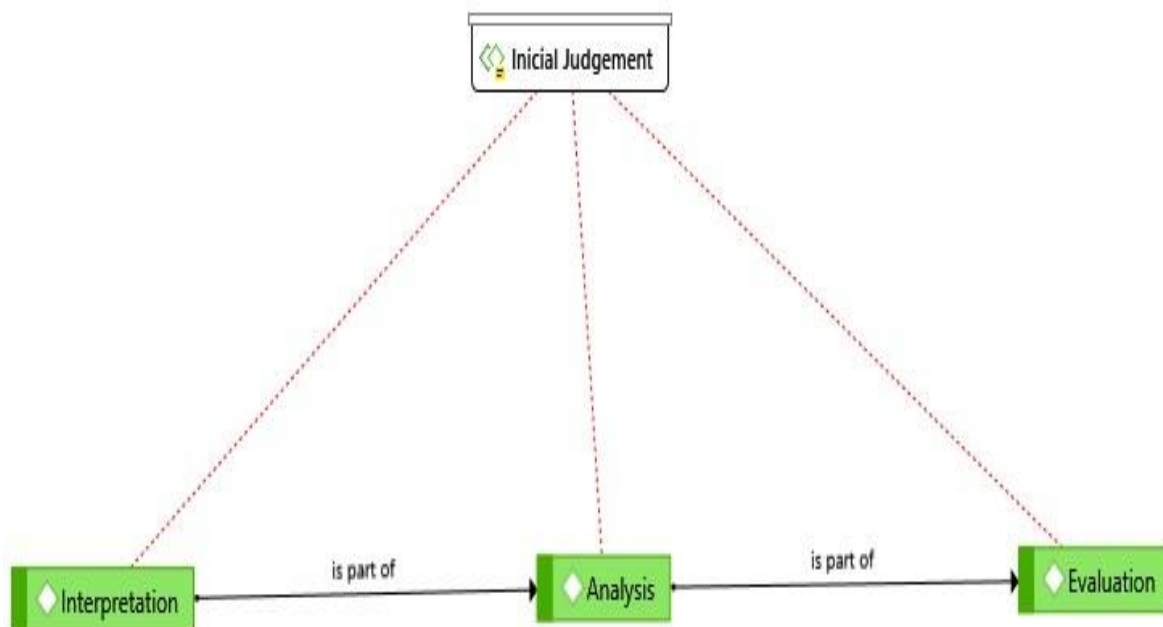
Figure 4.8: Initial Judgement Categories

As already mentioned, the criteria used were the semantics. At the main Unit (known as the Hermeneutics Unit), some categories emerged more clearly than others did. This means that both expressed and latent Contents are relevant for the results. The subjects explained their thinking better when faced with the web history in some situations, but they allowed the researchers to perceive some differences about their critical thinking and what was found in the literature review. For example, the categories of Analysis and Evaluation are distinct categories, according to Facione (2014). However, our subjects always placed themselves in a position to represent the analysis of the information followed immediately by a small superficial evaluation of the data obtained in the research.

The nodes of the following webs relate through a cause-and-effect construct: analysis gives an opportunity for the student, after analysing, to interpret closely what is being made available in terms of research, and then to make a judgment about the object (web page, search engine) and evaluate it.

a) The Analysis, Interpretation and Evaluation Categories

According to our studies, the categories of Analysis, Interpretation and Evaluation were confirmed as Initial Judgement level from beginners. This can be seen in the Atlas network:
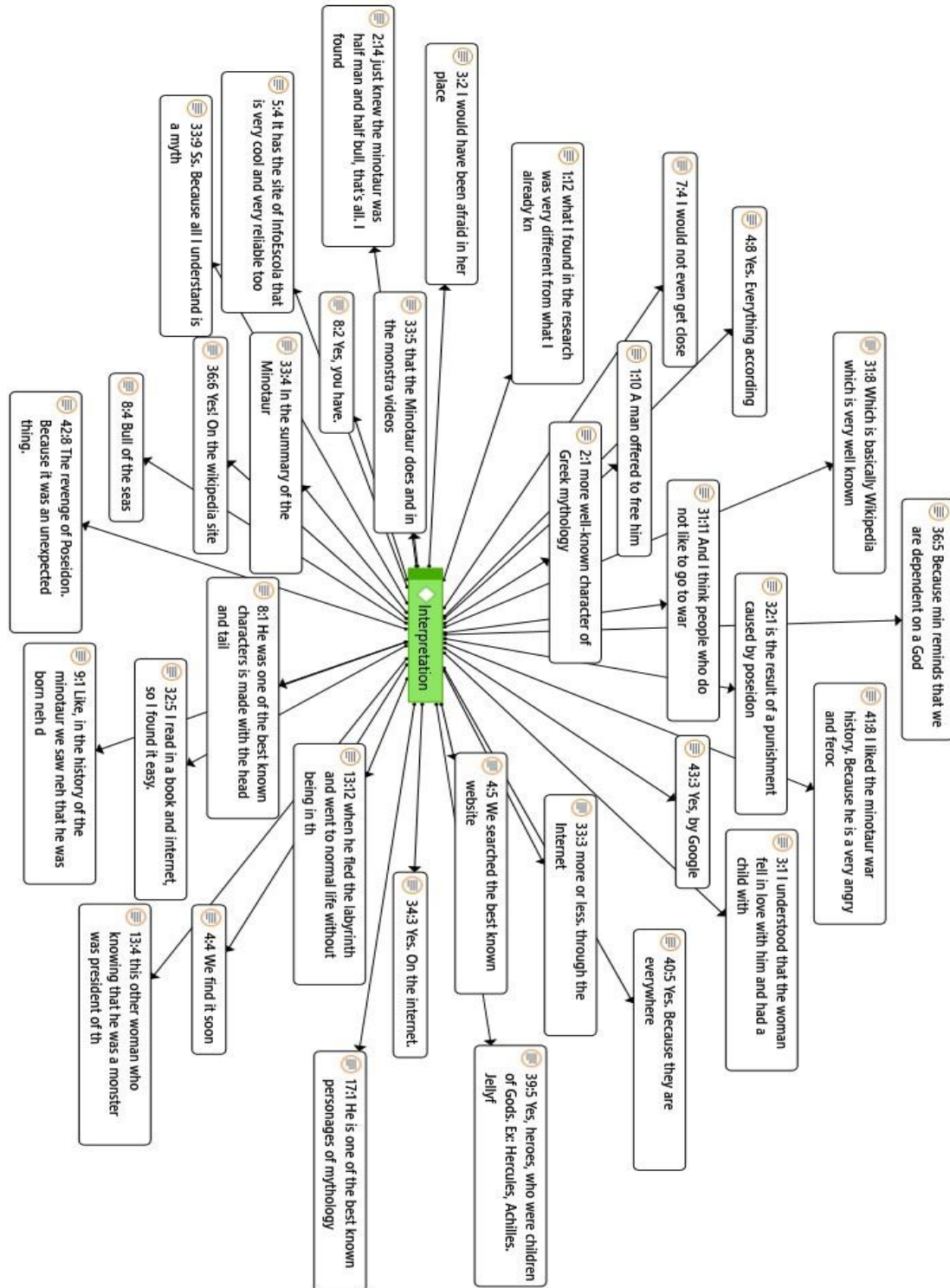

Figure 4.9: Interpretation Category

All students have been able to show Interpretation skills. Some more frequently than others, and the majority of them evolved quickly to the Interpretation level.

After interpreting their findings on search (images, videos, among others) students could then inferred with some security on the subject and produce their own conclusions about their findings on the web. In this way, the interpretation leads to the inferential process of students in their analysis and searches. The nodes of this web are related in the same causal way: one category (interpretation) is the cause of the other (inference), because there is no way to infer without previously interpreting (figure 4.8).

After searching and retrieving data from the in-room survey, none of the participants ended their search. All of them continued to search, even topics related to the theme proposed by the protocol, but they wanted to know more about the relationships of the researched object with reality. According to Demo (2011), "there is no way to emancipate someone, if that person does not take control of the process" (p.82), then we found we are facing an emancipatory attitude, even if incipient, on the part of the students.

In the above case, then, we conceive the **Analysis** as being part of the **Interpretation** and, consequently, of the **Evaluation**. Evaluation means the examination of the data obtained in the web search pages, when the participants decided how to use the data. The data that did not respond to the questions proposed by the teacher were categorized as Irrelevance (in case the student answered something meaningless) or Elementary Level (in case the student demonstrated that, at that moment of the interview, he was still at a level of Construction of the elementary thinking). None of the subjects, during their search, insisted on data that did not answer questions initially proposed by the research, which brings us to an interesting conclusion: the dynamics of the web makes the students quicker and more easily discard information considered useless or irrelevant. Another interesting point is: the participants answered primarily of the research problems.
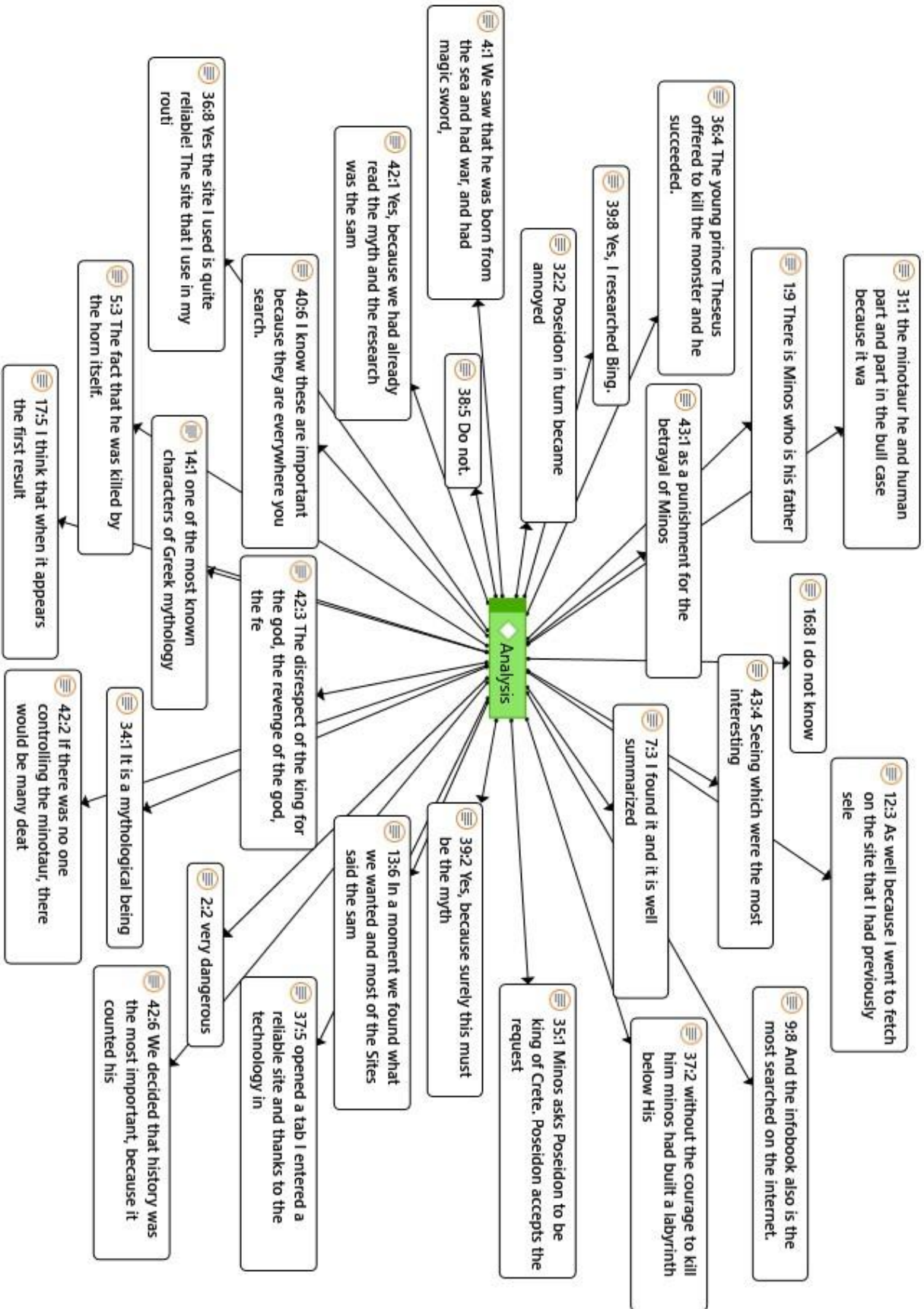
Figure 4.10: Analysis category

Normally at schools, at this point of research, regular schoolteachers consider the Research Question has been answered. There is the proposal of a search, the survey of the data and its analysis; then the evaluation and the research is finished. In this case, while looking for indications of critical thinking, these three categories were conceived as the first step toward the emergence of some criticalness from students. In the collection, the research protocol was designed in order to avoid the search ending in this initial phase. Some students showed that they were going a little further in their search, and were well judicious in their analysis.

The digital literacy means being able to interact in digital environments, that is, performing reading and writing practices that differ from traditional practices. It is knowing how to research, select, use the various tools available to fulfill various purposes. A person can use his ability to relate to their peers, to learn constantly, to build, to transform, to rebuild, to exercise authorship, to share knowledge, always using Web resources, or professional. In our research, it was necessary that the electronic literacy to include the knowledge and skills necessary to make a mark in an electronic era with electronic devices.

The Interpretation category had 34 occurrences in the results. In the Analysis category, the occurrences were found during the interview: 29 occurrences in all subjects surveyed, including online questionnaires. Some subjects were more evident in their interpretations and analysis, making evident the characteristics mentioned by Facione (2014). This occurred more often in subjects who did not have stronger critical thinking skills. However, we were still able to visualize the skills of Interpretation, Analysis and Assessment in critical thinkers from all levels.
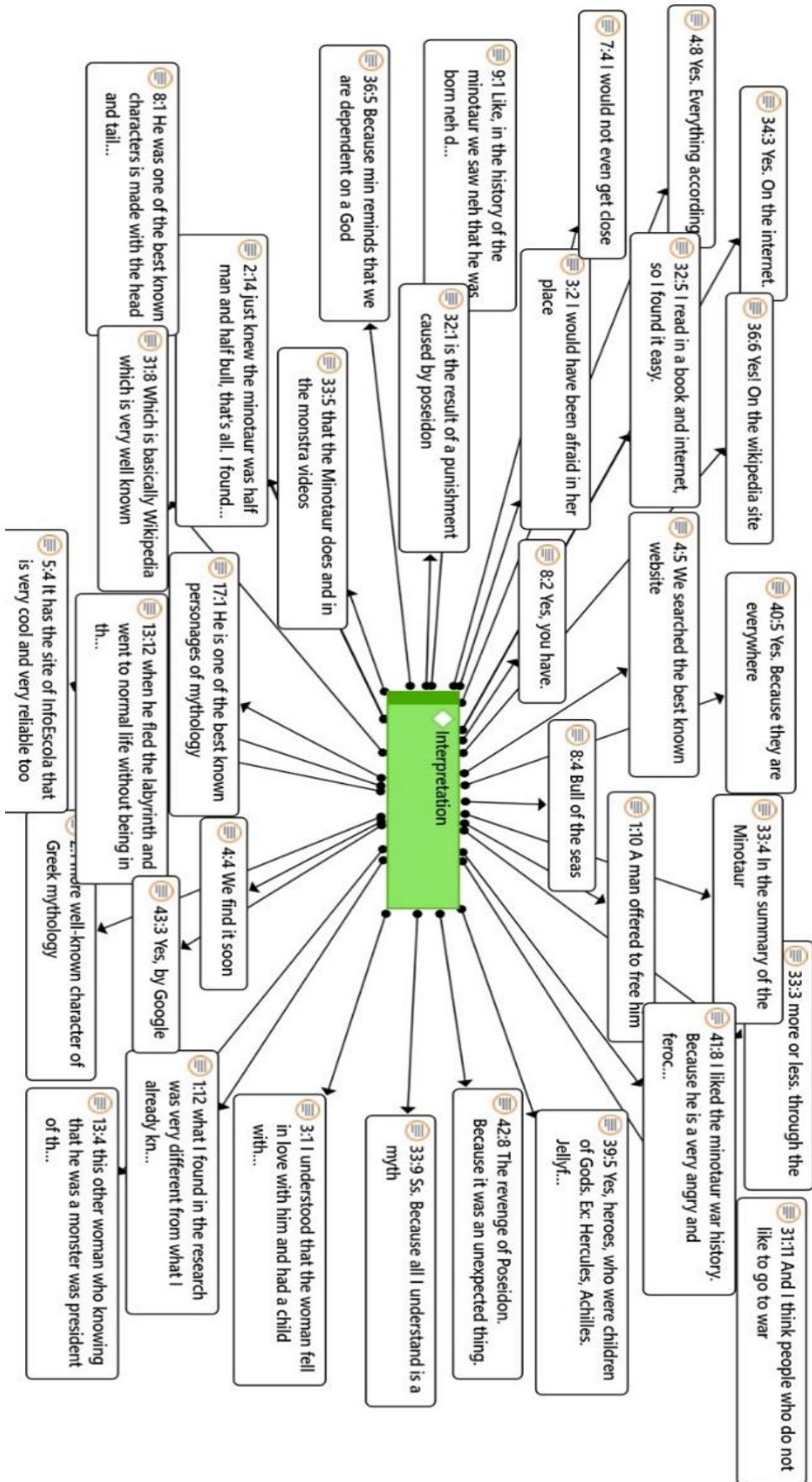
Figure 4.11: Interpretation Category

In Evaluation category, an increase was observed in the frequency of the participants' attempts to establish a judgment about the elements found in the web searches. Accessing the credibility of information and comparing it with other sources of information is an important and vital movement, supported by the very configuration of web search: participants know that comparing information and the credibility of sources is essential to the quality of data found.

It is really important to notice this category is where critical thinking is growing up. The person mobilize skills in order to evaluate and judge data, observing wrong concepts, imperfect reasoning, lack of precision and need of accuracy. At this moment, the participant makes a back-and-forward movement on web to find the precision and this movement is vital for the emergence of Critical Thinking.

The most usual criteria listed by participants to evaluate the information were: the time (how old was the information), relevance (in what extent the information answers the purposed question), Liability of source (Can I trust in this website?), and how accurate was the information. Intuitively, they seem to know how to search on internet and keep the average of information found on websites. They also paid attention on language used, the quality of written texts and rejected most of sources that was not visually or textually good. In order for the information available on the Internet seem to be credible, the participants developed some ways to determine the accuracy and reliability of results. Traditionally, what determines the accuracy of a source of information is the conference of references, the consistency of the bibliography, the citations, among other forms. However, what makes it difficult to examine sources on the Internet is the fact that they can refer, in the same way, to others of questionable credibility. Because of this, the student's research could not find only one version for the Minotaur myth, but at least three and all of them seemed reliable. It would be interesting propose a focus group where we would discuss this particular topic.

Thus, once the initial phase of critical thinking is confirmed or at least the mobilization of the main cognitive skills in order to establish it, we proceed to analyse the next level of critical thinking, the intermediate, with the category of analysis called Inference.
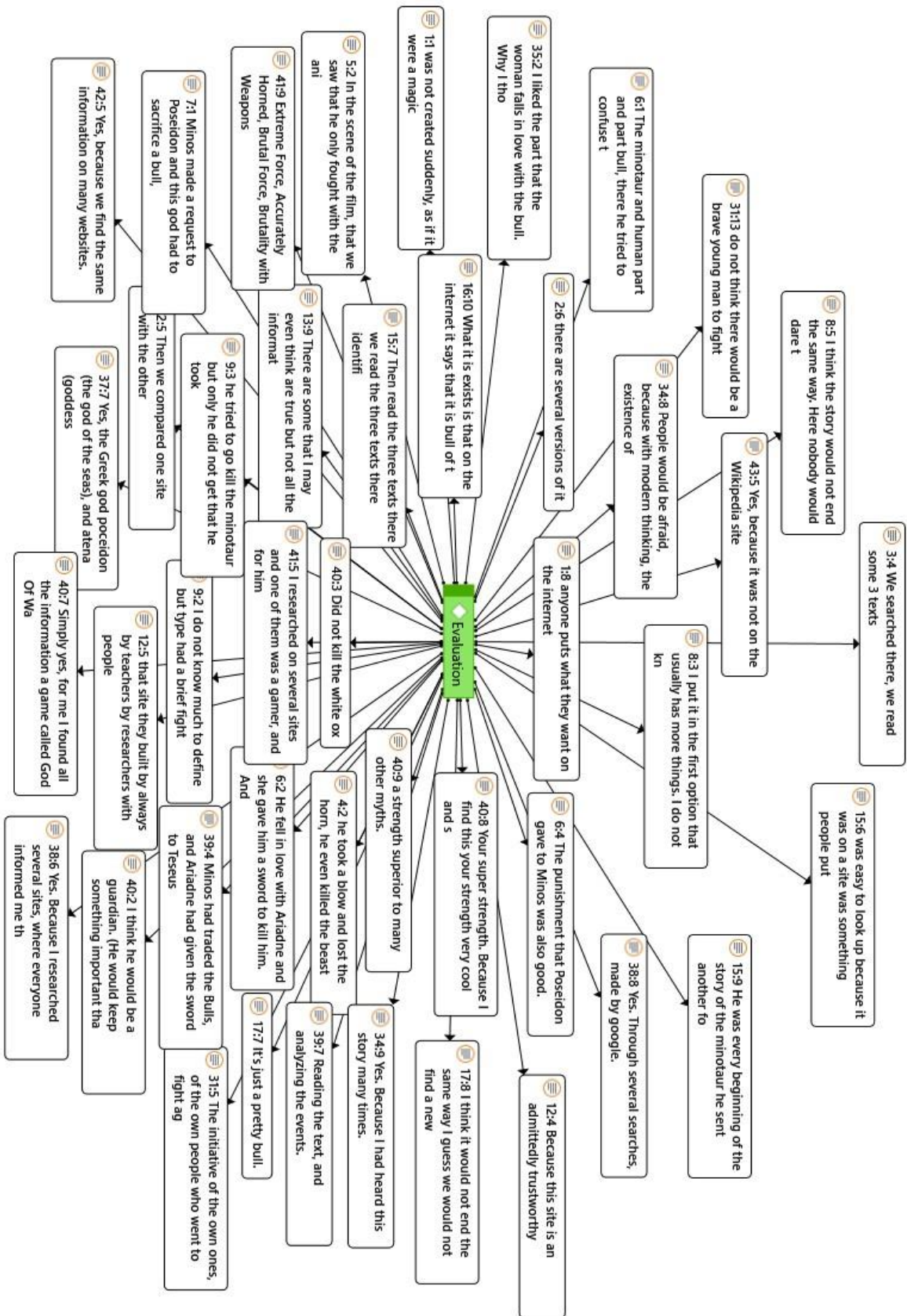
Figure 4.12: Evaluation Category

b) A deeper category of Critical thinking: inference.

According to Van Dijk and Kintsch (1983), in order for the understanding the text, he must be able to construct an adequate mental representation of the message, connecting the information during reading, at the most local level - of the sentences – and at the more general level of paragraphs or sections of the text (macrostructure). In this way, the inferences generated by the reader during reading play a fundamental role in the construction of meaning, since they provide the connections that integrate the information coming from the text, leading the reader to build a solid mental model that helps Comprehension, retention and future access to the memory of the information read. In data analysis, this phenomenon can be clearly observed through attempts to establish cause and effect relationships, establishing hypotheses. Here, the participant's approximation of the researched object is perceived in order to know better the object studied and to validate (or not) its hypotheses.

The Inference category, in our study, was the largest: 75 occurrences. This result is explained by the movement that the participant makes in order to validate his various possibilities: a participant establishes two or three possibilities for each item of data and, thus, makes the movement in search of the validation of each one of its possibilities of research. Within the participants surveyed, only three of them did not make an evident and unmistakable movement of inference in the formulation of their hypotheses.
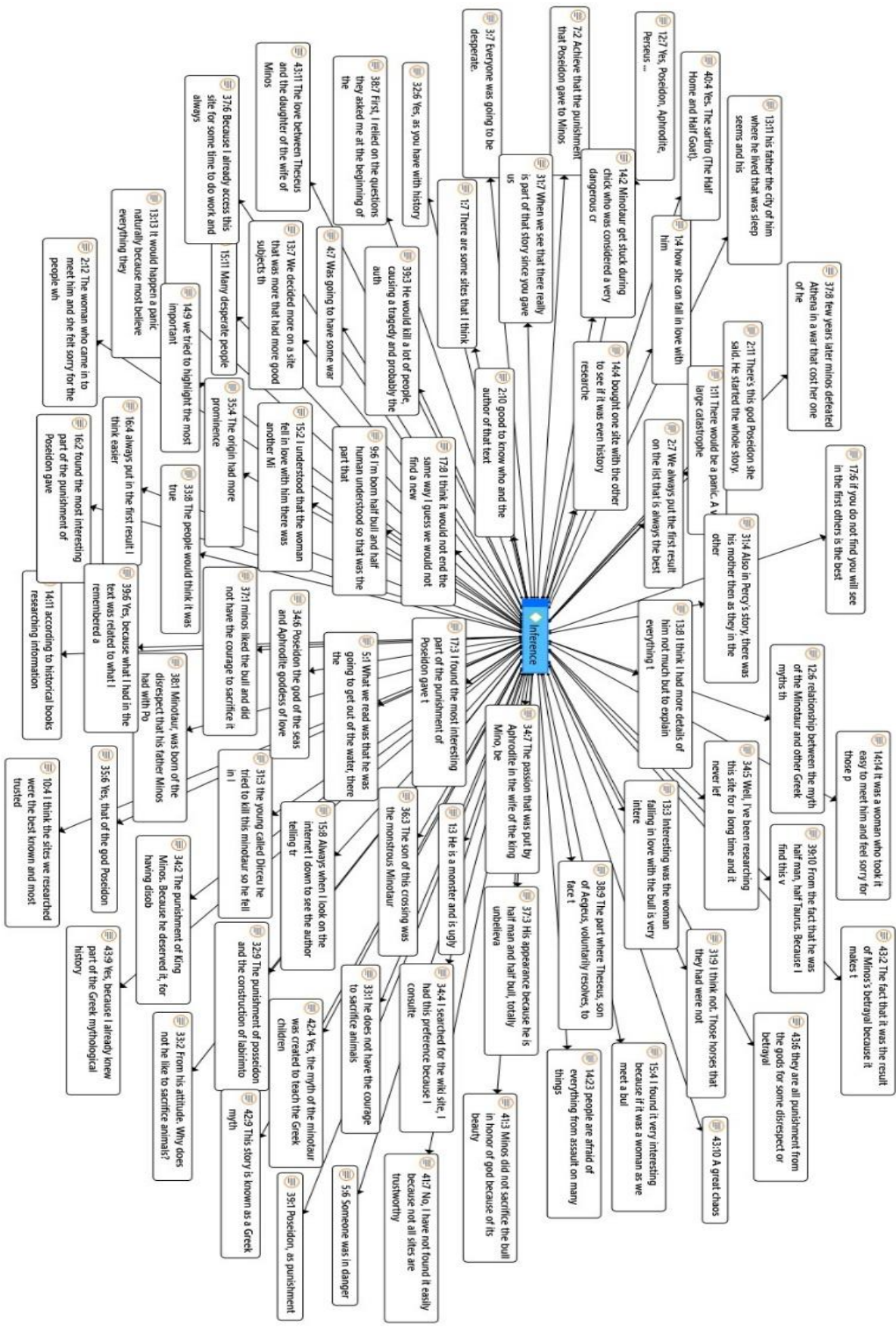
Figure 4.13: Inference Category

However, from this stage, we see a narrowing regarding the results of the next steps: many students are confused or simply give up the validation of their hypotheses; others recognize that the search has not yet been completed and that thought needs to be deepened in order for its hypotheses to be validated. Here we find clearly the entropic movement we deal with in the theoretical framework.

c) The entropic movement: resultant categories
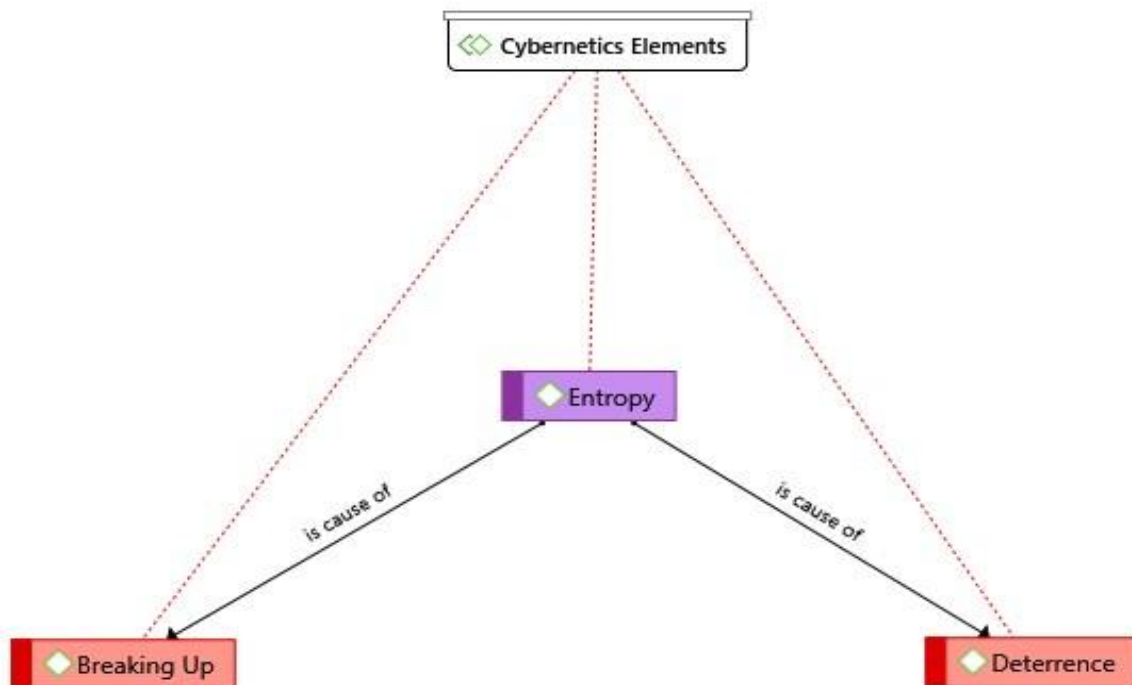
Figure 4.14: The Entropy

Wiener (1948) associated entropy with the process of communication / information, when he states that, in processes where information is lost, there is a situation analogous to processes that gain entropy. The next step was given by Brillouin who equated information with negentropy, that is, the information needed to change a system from one state to another, more orderly, one.

It is the meaning of Wiener's entropy that we refer to when we speak of entropy in the system represented by the mechanism of critical thinking. This increase in disorder in the system of organized thought is clearly perceived through data collection and categorization.

When there was an increase in entropy, participants opted for one of two paths:

(a) In order to reduce the discomfort caused by the internal conflict of thought, and thus stabilize the whole system, the participant chooses to close the conflict abruptly, ending the searches, interrupting the inferential activity, and in essence returning to the point where he began his search.

(b) They intensify the search and the questions become more complex, they mobilize two other critical thinking skills (Explanation and Self-regulation) until they can stabilize the system by breaking with the old, pre-established reasoning, their own understanding of reality.

Category "Fear": the Deterrence phenomenon

The Deterrence category has been previously classified as "Fear" (Valle and Abranches, 2011; Valle, 2016), but after the deep study of entropy and complexity phenomena, it has been named by the researcher as Deterrence in this study. According to the phenomenon character, something happens and the student stops some kind of conflict while facing some threat or strange element. This is definitely related to Deterrence etymology.

It is important to note that not everyone who follows the path to Deterrence will be able to mobilize the critical thinking skills themselves, moving on to deepening understanding. These participants chose to restrict themselves to an elementary level of criticism because entropy and external factors caused them discomfort. According to the cybernetic principle of Selective Retention, this would be a natural path to be made. In this issue, 13 students made this choice.

After finishing their searches and inquiries, inferences, and reconstructions through Deterrence, the participant returns to the initial state in terms of thought and criticism. He can always retrace the path of disruption with all the established status, but at another time.

The moment he ends his activities, he must interact again with the environment in order to
foster new entropic moments.
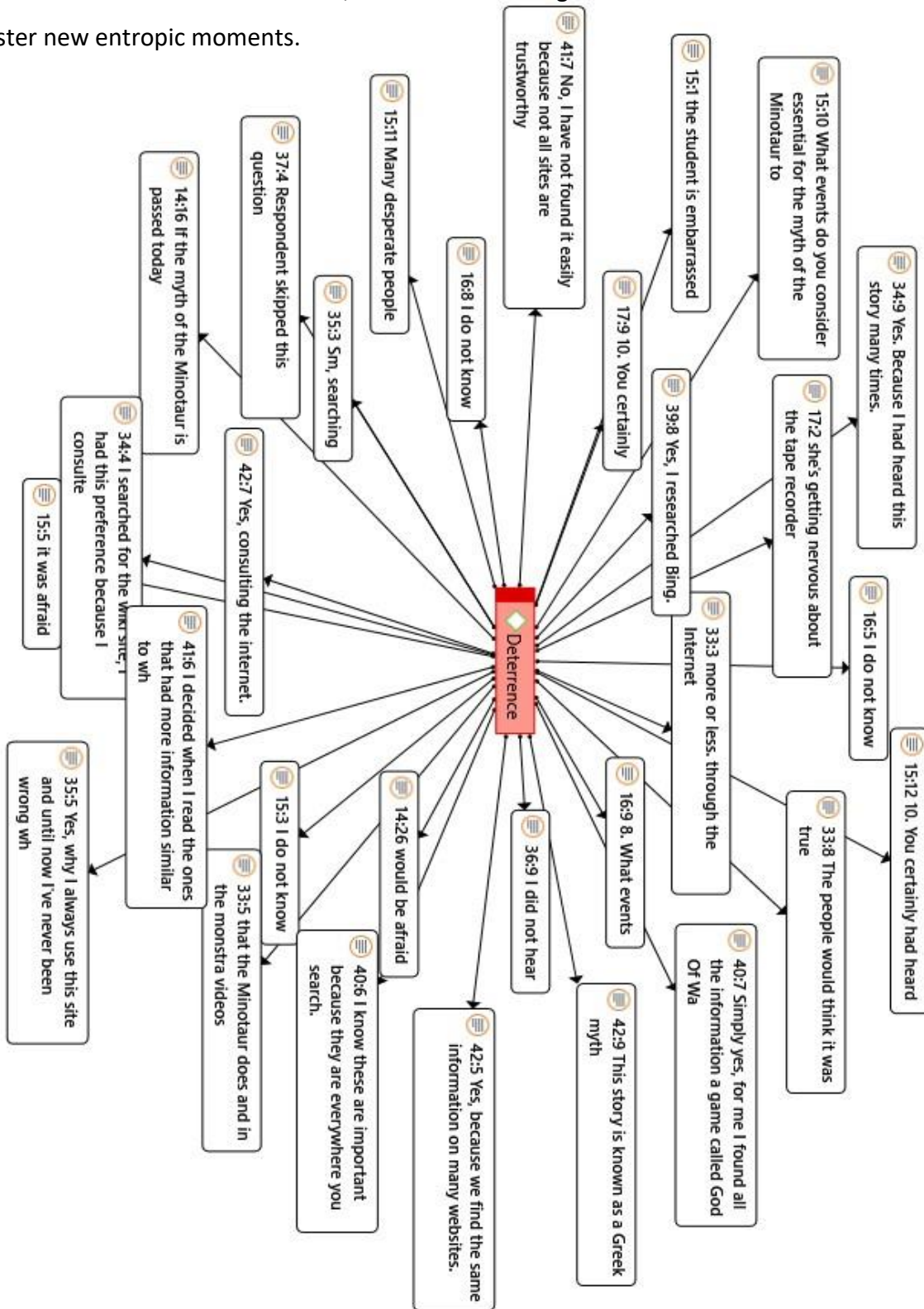
Figure 4.15: Deterrence

"Breaking" Category: emerging as an Entropic phenomenon

While some participants broke their previous thinking and decided to go further, they did so for several reasons. There were several justifications presented by the students, but what they brought in common was always a strong desire to go further in research, and to draw their own conclusions so that they would be satisfied with the explanations offered, or rebuild the main search meanings for the objects. All the subjects of this category broke with the initial project of search, went further in their elaborations and constructions, returning with their own conclusions. Often, the participants' conclusions conflicted with their own concepts about some object studied before the research, and these students were able to reformulate the own thought.

Some students said they were not satisfied with what they received from information on the website presented. They decided to confront and compare sources, and even question their credibility. This movement, it seems, is fundamental to the emergence of strong critical thinking skills. Look at the examples:

> D12:CI4 I used to think it was just a bull that got stuck. Now I know that this is a more complicated thing.
> D38:SMA7 First, I relied on the questions they asked me at the beginning of the survey, and then several other important pieces of information emerged.

Participants who fit into this category believe the information contained on the site may be completed by other sources (videos, other colleagues, songs, blogs, images), validated or may not be reliable. The dynamics of web search makes the student, assuming that some more complex searches will need to be validated through several searches. Then a complex and different result will emerge from what is available on the sites. Perhaps because of this, is possible to see relevant authorship content by young people: audio, video, blogs, microblogs, image editing, anyway, everything is authored.
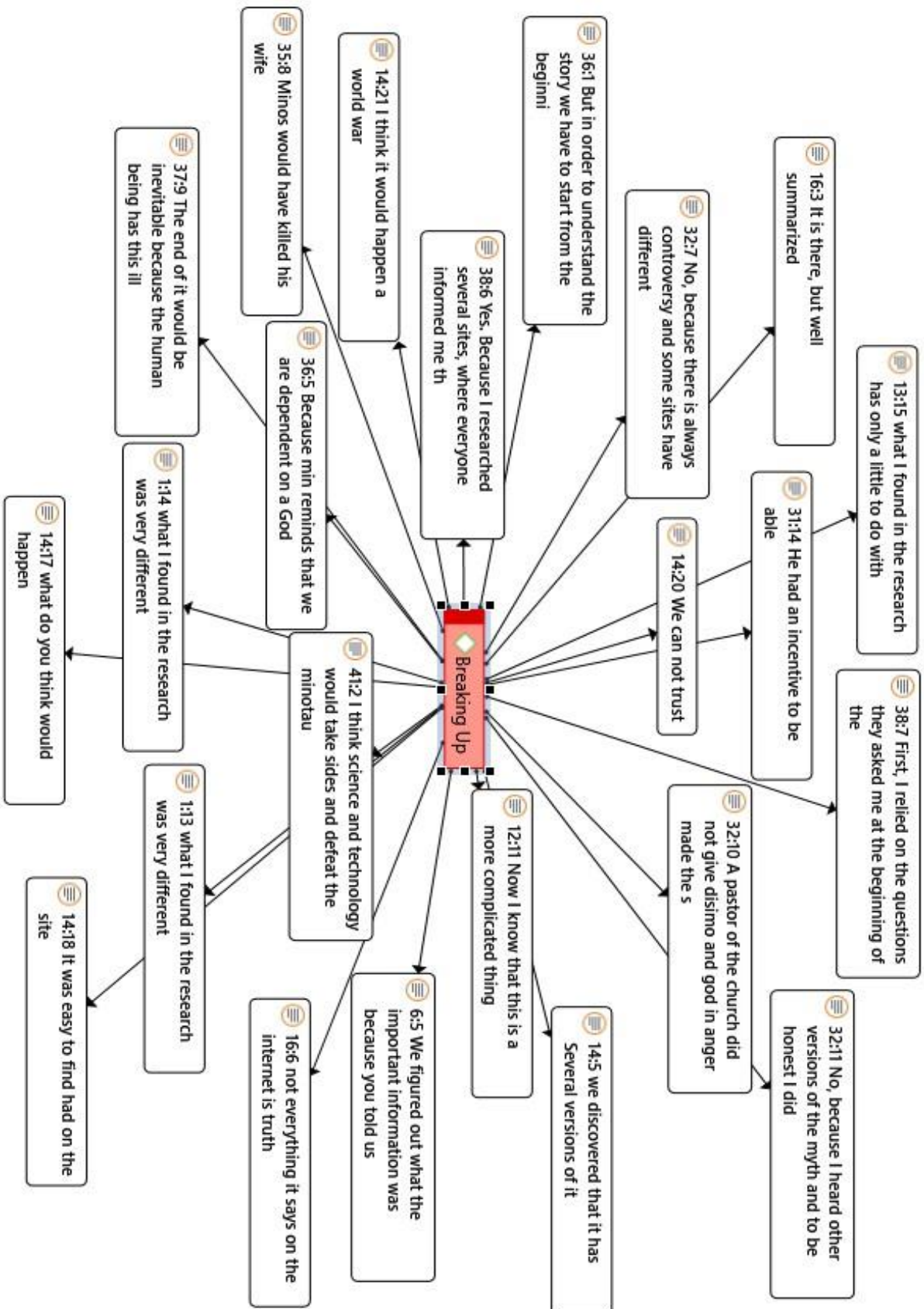
Figure 4.16: Breaking up

At this point, participants mobilize Explaining and Self-regulation skills. It is important to note that not all participants who break with established thinking go from the Explanation to the Self-regulation phase. Only 28% of respondents could be classified as critical thinkers capable of redirecting their own thinking: the category of critical thinking itself (Facione, 2014).

Self-regulation, in mathematical terms, would be the recursive function that would be applied to all agents, including ourselves. To activate this ability, the subject needs to mobilize the metacognitive function. As Facione (2014) says:

> This ability is remarkable because it allows strong critical thinkers to improve their own thinking. In a sense this is critical thinking applied to itself. Because of that some people want to call this "metacognition," meaning it raises thinking to another level.

According to Jou and Sperb (2006) metacognition is the approach of cognitive psychology to information processing, which postulates that the mind is a cognitive system through which it interacts with the environment. In this process there is monitoring, self-regulation and empowerment of the system itself. Metacognition is not only a knowledge about cognition, but a stage of high-level processing, which is acquired and developed by experience and the specific knowledge that is stored. These authors also postulate that metacognition is an evolutionary achievement of the human being, due to the need to adapt to the environment.

Strong critical thinkers are even capable of deconstructing their own thinking and reformulating it, moving in another direction. In cybernetic terms, after the entropy that gave origin to the disorganization of the original thought, the moment of self-organization of the thought arises through the reconstruction of a new idea. Those who pass through this phase are considered critical thinkers, returning to the initial phase of interaction with the environment. Since the learner never ceases to learn, we see the process of feedback.

Summary:

Accordingly to our findings in the first study in 2011, there was an unexplored and nebular region within the critical thinking. To access the Cognition region, another study was performed in 2016 with 32 students, performing a research protocol on web, using as data collection the tools of the online questionnaire and the Clinical Interview, while participants completed a web-based research protocol. As data analysis instruments, the content analysis was chosen to perform all the qualitative data analysis. With the results, the cognitive region became clearer, and it was possible observe two different phenomena, clearly linked with the Cybernetics Entropic Movement, named in our study as Deterrence and Breaking Up. This entropic movement was considered the key point to foster critical thinking, once it is result of the reorganization of ideas and concepts while performing a research.

Chapter 5

Interpretations of the Methodological Journeys: The Model

Chapter 5: Interpretations of the Methodological Journeys: The Model

The preliminary study was very important in providing us with information about effective data collection instruments throughout the process. It was also important because it provided data on the operation of critical thinking and the elements that could interfere with it. Nevertheless, we realized from the preliminary study that to effectively understand how human critical thinking would develop while using digital devices, a better approximation of the phenomenon and a search for sources that were not available in the conventional theories of Education would be necessary. The phenomenon comprehension within an approach supported by other theories that considered it as complex and holistic should be made for a complete understanding of the phenomenon.

The clinical interview proved to be the most appropriate instrument since it provided an opportunity for the expected data to appear. As a consequence of the technique adapted for digital devices, it was possible to perceive the complexity of building critical thinking and its formation at each moment of conflict. A greater clarity was observed in the participants' interviews about their perceptions, conflicts and desires at the time of the proposed research, without diminishing their freedom, through a videography. The students explained their search processes on the internet using the history of research done on the computer, in previous activity.

The categories of Critical Thinking chosen *a priori* were (A) Analysis and Evaluation, (B) Interpretation and Inference, (C) Explanation, (D) Accompaniment and (E) Ability to correct own reasoning, considering skills present and frequent in critical thinking (Facione, 2014). During pre-analysis of data, categories that were observed previously for explaining some phenomena or simply for influencing them have reappeared more strongly: (F) Fear (of teacher's authority); (G) Breaking out (with teacher-oriented pattern / research proposal). In the "Fear" sub-category, some data indicated that the thinking and reworking movement from which critical thinking turns out to be strongly influenced by the student's fear of breaking the internet search rules established in the classroom. The "Breaking out" category already brings movement in the opposite direction: students who, despite receiving the

guidance to research the laptop in a certain way, found a way to circumvent the rules and broke the guidelines, establishing their own results after the research.

When the phenomenon was observed on the main study, it was the main objective to recognize in the students' statements during the clinical interview the confirmation - or not - of the hypotheses established during the proposition of a science for the construction of critical thinking. Thus, the cybernetic construction of critical thinking could be established and the understanding of the complex phenomenon became evident.

5.1 Cyber constructions at Liquid Times

The interviews performed with children during this study can follow the same point of view to some social theorists who advocate the complexity is not a novelty today, considering that since the social being exists, it already presupposes the presence of complexity. Is not possible ignore the complexity of thinking presented by children, as it could be a downsizing and misleading path. For social sciences, thinking of complexity, it is possible to begin a dialogue about the intricate mazes of existence itself.

Science is, and continues to be, an adventure that daily allows the challenge of its own structures of thought. Bronovski said that the concept of science is neither static nor eternal. Perhaps we are in a critical moment when the very concept of science is changing (Patil, 2014). In the course of considering these questions, the dominant paradigm[5] supports the idea of the disjunction of the object and subject, of the soul of the body, of existence and of essence, reducing being and knowledge (Morin, 2014).

From these reflections, the paradigm of complexity arises, based on the distinction, on the conjunction and the mutual interaction. The brain involves the mind and vice versa. The mind can only emerge from a brain situated within a culture, and the brain can only be recognized by a mind. Moreover, thought that is complex, which is woven together, cannot be linear, since it integrates the simplifying modes of thinking and, consequently, denies the mutilating and reductionist results, committing itself to the amplification of knowledge (Nielsen,2016).

This amplification of knowledge leads to the inseparability of knowledge and action,

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[5] Dominant paradigm can be understood as the model of learning or knowledge acquisition proposed at schools.

as all mental knowledge builds strategies for solving problems that challenge us by the current uncertainties and incompleteness of knowledge (Valle & Abranches, 2011). The data collected in our study point to this reality: the critical thinking found was possible to be classified as complex (non-linear) and presented modifications and direct influences of society in Network. According to Levy (2001), Cyberspace is the result of the interaction between physical and linguistic aspects: the space where, effectively, sits the Cybernetics field.

The online condition implies the relationship and sociability at online environments. It presupposes interactivity, the existence of a place to enter and to leave. On this, the sociability on the Internet has its rules, its nation, its own language, its crimes, its offenses, and it configures those that inhabit it, instituting labels, social norms, habits, customs, constituting another culture. The participants of the Main Study already know this environment well, as distinct from the participants of the Pilot Study, and could find some ways to operate in internet more like natives of a system. This must be considered while reading the results from both studies Undertaken seven years apart, during which time society has changed.

From this analysis, it is possible to assume that Cyberspace, where Cyberculture happens, is an environment of belonging, where there is identification by origin. The territoriality as previously known disappears and a new territoriality arises, which is related to the location of the servers that store the information, subjects that are to the traditional territorialities for its installation. The Cyberculture tribes have their own rituals, while people become members of a new community, assuming positions and behaviours related to that tribe, and the territoriality that is present here is not a country, a city or a continuous geographic physical subset. These "tribal territories" are information and contacts dispersed by the participants' computers, and only accessible in a network.

5.1.1 Cultural Understandings

For education, the movements of collaborative processes are of fundamental importance since they potentially enable the understanding that contemporary technological devices, are elements that contribute to the construction of other social practices. The digital world, and the internet, drastically reconfigure, as Gerbaudo (2018) states, the basic conditions of speech and reception, since the internet is more a social space than an object.

In this way, understanding the internet and, along with it, all other digital technologies that are articulated in a process of technological convergence, means thinking them not as mere tools to knowledge production and education (Hodkinson, 2016).

In the postmodernity [6] , the Internet is an effective communication tool that advances the objectives of its users, understood as an instrumental identity. Differently from the "effective communication tool" perspective, it is possible to think about the internet and all digital technologies, in society, in school and in education in general, as elements that have contributed to a radical transformation of both society and education, boosting the Digital Age and becoming one of the greatest research challenges in the contemporary world. However, these transformations do not correspond, in most cases, to the way in which public policies are elaborated, or how educational processes are established, bringing to the contemporary scenario great confrontations. The Brazilian example in the field of culture may be useful for a better understanding of this time. Bringing to this discussion the movement around the exchange of files through systems, is possible observe they are distributed, non-hierarchical and decentralized networks. Each user, that is, each computer in the network, can exercise the role of client and server, without central management, causing the information to travel fast.

This type of network has gained popularity from music-sharing programs, initially only associated with the mp3 (proprietary) format, but now also used for the circulation of music, movies, videos and software. With all this, the appropriation that the youth has been making of these technological devices has enabled him to go beyond the mere consumption of information: it is intensively producing cultures and knowledge. Youtubers are the new "glamorous", and there exists the largest taxi company in the world without a car (Uber); and the most important delivery company that does not employ deliverers (Deliveroo).

Now more than ever before, people get in touch with each other using the written word: the social network, the chat, the private message and after all of this, the meeting. It needs to be clear that access to all these resources of information and communication is fundamental so that, effectively, the student population can discover and live with what we call Cyberculture. These are the youngsters that arrive at school, a school that is experiencing

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[6] The postmodernity is the concept created by Zygmunt Bauman, (2013a) aiming to address the consumer society product of the Digital Age, in the third millennium. After some academic debate, Bauman replaced the term "post modernity" with "Liquid Modernity".

a crisis for different causes and historical reasons, one of which is related to population growth and the number of students to be served or a school that cannot work with the diversity of cultures of those who arrive there. It means that initiatives involving critical thinking and its consequences have been left behind: the priority was based on standardization and the introduction of practices centred on a logic that is more similar to the production line of an industry than to processes of scientific and cultural production.

5.1.2 Answers that concern (fear)

According to Freire (1996), "freedom" begins while the human being recognizes a system of relations of oppression, and his own place inside that system. Changing the consciousness and concrete actions are consequential actions for Freire, and the greatest barrier to the only possibility of liberation is a belief, rooted in the inevitability and necessity of an unfair status quo. However, the following categories reflect the situation in which the self-regulatory system of the classroom still provides a repressive impact on the creativity and initiative of these young researchers: the "fear" category shows that, for various reasons, students did not progress because they were in fear of something. It was reported that students feared that they would not dare do much more in their research, or go further. When questioned, the answers were the most varied.

The concern of teacher's power is still awake in students in the digital age, making everything in their speeches suspect and even feared. It makes some students not want to go ahead in their searches just because "the teacher said so," missing the opportunity to rework their thinking. This subcategory has emerged in comments such as:

> D5:S2: there you write in the notebook and show the teacher
> D10:S3: I know it was right because it was the site that the teacher had to search
> D17:S4: Because the teacher said it was
> D11:S4: I ask the teacher

This category would express with great force the student's fear of making mistakes, in front of someone who has all the knowledge. There is still the fear of evaluation, meaning that some activities can interfere in grading, and students would not dare to search differently for fear of taking low grades during the activity. In this way, what kept children from going

beyond and creating something as they imagined or desired was the obligation to have a research result "as the teacher wants", regardless of whether the later construction with his own thought and direction would be well more constructive and emancipatory. His critical thinking ran up against the bureaucracy of evaluation.

Students frequently showed a fear of breaking established search rules, limited by this fear, and becoming frustrated in their quest. The search ends without the student satisfying their curiosity and exploiting their full potential:

> Interviewer: And you were satisfied with the answer?
> D5:S1: more or less. Class is over and I have not seen the right labyrinth

> *[another situation, the student complained he was ready for the interview but wanted keep searching]*

> Interviewer: Were you ready? Did you do anything else later?
> D11:S5: this is not the end of the research. It has so much more [looks like frustration]

Whether it was by choice or by the way research situations were proposed, these students finalized their searches early, indicating that they wished they had gone a little further. There was a potential to be explored yet and they would have wanted to have done so, but no favourable conditions were set for this new exploration and, because of their concerns, they finished. This situation reminds us of Demo's words:

> It is a fantastic mistake to imagine that "pedagogical contact" is established in an environment of transference and copying, or in the debased relation of a copied subject (teacher, also an object, if he only teaches copying) in front of a receptive object), condemned to listen to classes, to take notes, to memorize and to go for exams. The lesson copied does not build anything distinctive, and so it educates no more than gossip, the chatter of neighbours, the chat at a lively party (2014, p 15)

In the assessments and notes that Demo made, it looks like the unique purpose of schools is still to pass exams. Consequently, the copied and non-constructive class seems to have its place guaranteed; it seems school is looking for new ways of producing and experiencing something old. Contents, curricula, skills, everything in contemporary school would need to be reformulated. New objectives and bringing a more open vision of what it

really would be behind certain skills and abilities of the students, taking as a model a school that does not teach copying but to produce, experience, question, rework, reformulate. There also emerged another type of fear, in the data collection: the fear connected with anxiety and the fear of thinking differently. It can be seen in the following sentence:

> S2: I learned a lot of new and different things but sometimes I'll go back to thinking as before. It is preferable, before all that has been seen, to return to "think as before".

Intuitively, these children note that very different thinking would be to some extent undesirable. According to the words of Demo (2015), we see that "... the child is by inclination a persistent, compulsive researcher. The school often disturbs this childish voluptuousness, using excess discipline, order, subservient attention, imitation of adult behaviour "(p.11). And it is this excess of discipline that brings such attitudes on the student's part: the imitation of "equals," and the fear of looking different. What sets the latter apart is that the fear of dare is expressed consciously in the boy's speech:

> D01:S13: I write the first impressions in my notebook and ask my friends to check if it is right.

In this sentence, the student expresses that he is afraid to dare in his searches. He is "ok" on being like others, and other questions seems not bother him. The curiosity was not enough to get him out of his comfort zone. He is aware of his own fear and makes sure he will not make any mistake by taking notes. According to Demo (2014), "it would be 'pedagogism' to invent easily transforming impacts, in such a precarious environment most of the time" (p.24). In this context, it would be desirable that the changes that we need to see in schools do not begin with some public policy as a "miracle" in education, but as a result of the initial academic formation of the emancipating teacher, not limiting, with open-minded and critical teachers.

In fact, it is possible to see that students who demonstrated fear or concerns have stopped their searches. In almost all participants the entropic moment was observed, in which every student faces their research and their possibilities. While some of them took the opportunity to expand their curiosity and gain knowledge about the Greek Mythology, others

just satisfied themselves by being bureaucratic and answering the questions. The second group, the "Fear" ones, while asked in clinical interviews why they did it, they just answered demonstrating their concerns about teacher, school, evaluation, and the fear of being wrong. This was in spite of the fact that they had previously been told the web-based activity would not be evaluated; it was purely recreational.

5.1.3 Answers that disturb (breaking up)

Some elements showed up with great force in our study. It is not possible to ignore them, because they are decisive elements that directly impinge upon the formation of critical thinking and student's cognition, to the point of making them insist on obtaining a satisfactory answer or give up their line of reasoning undertaken so far in the search on the web.

Again, it was possible to observe the categories presented more as variables of the process of formation of the critical thinking. The nature of the categories do not allow us to classify them as elements of critical thinking. Although, they relate directly to the process, they are not categories directly related to the thought or the criticality abilities, but they are related to the situations in the surroundings of the web search, the pedagogical conditions created by the teacher / school, and the student's own attitude towards the position occupied by the teacher in the school hierarchy.

These are the categories of "Breaking" (with the programming and the rules established by the teacher) and "Fear" (of the teacher's authority, to establish the wrong reasoning, not to give time to finish the work).

Facione (2007) says that it is not everyone who will mobilize critical thinking skills, but "a person who presents 'a critical spirit'". According to him, presenting a critical spirit means "a curiosity in the survey, a keenness of mind, a zealous dedication to reason, and a hunger or willingness to gather reliable information" (2007, p.10). Thus, in order for students to genuinely develop critical thinking skills, it is desirable for them to break with the teacher's pre-established schedule, already in place. And that was what happened in the "breaking up" category.

When the subjects broke the initial proposal of the web search presented by the teacher, they did it for several reasons. So, we subcategorize it according to the reasons that led the students to break the initial schedule, as it is possible to see in the category below.

However, all participants in this category "broke" the original search project and have been able to find their own reliable or different answers.

It was necessary for some students to look deeply into some definitions and concepts to formulate a satisfactory version for their research. This primary curiosity was found in almost every student. Nevertheless, just some of them could effectively break the **e**stablished standard thinking and go beyond, mobilizing deeper critical thinking skills. As an example, it is possible bring two of some participant's observations that lead us to observe this:

> *When you searched the information on the internet, how did you decide which were the most important?*
>
> D38:SMA7 – First, I relied on the questions they asked me at the beginning of the survey, and then several other important information emerged.
>
> D5: CI17 – I read three texts, so I tried to identify one that would have the essential elements or what are similar on them and I decided

The participant named as D38:SMA7, explained he had some of those questions and tried to follow the steps but at some point he decided there was much important information and he should search more, to produce a better result. He was one of the participants who used the computer for a longer time. The participant named as D5:CI17 said something important about her research criteria. She built the final result by evaluating results of her search, established similarities and created another text with the elements she thought would make a reliable story for the search. In her case, she mobilized some important critical thinking skills and was able to break up with the original results, questioning the reliability of them, bringing another valuable result of his/her own.

Some students stated they were not satisfied with what they received as information from the website presented. They believed that the information contained on the site is not valid, so they made a search on other portals. The dissatisfaction with the proposed programming brings a favourable situation for the ***breaking up*** condition to emerge. They also relate to the nodes of the web in a causal way: dissatisfaction with the search causes the student to break with the pre-programmed paths. It also can bring the ideal condition to encourage independent thinkers to provide their own answers.

Another reason for disruption with the initial search was the desire to go further in the research. The subjects reported being satisfied with the information obtained in the

searches, but wished they knew more about the subject matter, their environment and possible relationships, making in the searches not a dispersive movement, but a movement of deepening of knowledge. Their curiosity led them to deepen their knowledge about the object researched. On this question, we can observe the comments of the following subjects:

> D3:CI8: Then I went to see the labyrinth... that's it!
> D4:CI9: It was ... I wanted to know if Greece is very far ... if it still exists ...
> D2:CI7: I went to see what a Minotaur was ... I found out ...

The participant labelled as D3:CI8 stated he moved outside the proposed task because he wanted to see The Labyrinth. He seemed guilty and not so sure about what he had done, if it was "right" or not, but his curiosity, like Alice through the rabbit hole, brought him to a new discovery. And he moved on. The same reason was enough to bring participants D4:CI9 and D2:CI7 to the same discovery, which leads us to conclusion that human curiosity and discovering is still the most motivating element to be stimulated while considering **breaking up** and critical thinking.

These statements were related to the research protocol proposed by the researcher regarding the "Minotaur". After reading about the legend of Minotaur, they apparently trusted ~~on~~ what they had as information and wanted to go deeper: they tried to get to know the Minotaur of the same legend, their labyrinth in image searches and Greece. Then, they found there were some discrepancies with the Minotaur myth and looked for more information on web. All three participants reported that they finalized the searches but because of the time they probably would take a bit longer to have a better picture of the proposed search results. This brings us another point, already proposed by Constructivists: every person has his own time to learn, to deal with the object of his knowledge, to understand and modify this object. Still, establishing a deadline to finish activities while human learning is happening remains a bad idea.

It is possible to argue this group of children in the "*breaking up*" category are related by *association*: this type of disruption is associated with the fact that the original research protocols have been broken *because* children were interested in what was proposed and wish to deepen their knowledge. This would not happen if the student, for any reason, just finished the research as exactly predicted, just answering the questions proposed.

Some participants wanted to supplement the information provided to them. So, they just moved to see a photo of Minotaur or watched a video. This movement of search within the web is inside the main proposition of the activity and, although it is not in the initial programming, we consider that this search is still within what was proposed and it was not considered a proper *"breaking up"*.

The last reason for disruption was the student who comes out completely from the research and the topic addressed to, for example, enter into games or entertainment sites, as noted in the history. Here, there is a complete break with the programming established by the teacher plus the proposal of search in the web. These search movements have not been considered as "Breaking up" category, as well. Although these events were to some extent expected, it was surprising how it appeared so less often than anticipated, revealing that perhaps there is a greater dynamic behind the involvement of students with the web search while engaged.

As we have seen, not all "rupture" on search or established protocol can be considered as a "Breaking Up" movement. What characterizes the Breaking Up properly is the movement to deepen concepts and mobilize the skills of explanation and self-regulation to complete the meaning of the complex phenomenon. After this, the person will have a reformulated idea of a phenomenon, probably with some change of mind.

The ability of these students to resize and redirect their searches would be something expected of a critical thinker of the Digital Age. However, we know that the skills demonstrated here are still very incipient, even if they aimed at that moment to deepen content. The judgment that these students present, for example, from certain sources of information shows that they already perceive, albeit intuitively, the importance of not giving up effort in a web search without a positive result.

5.2 Critical thinking as a system

As we have seen, "Fear" is a decisive element which refers to fears and uncertainties associated with the research process. This was expressed in the clinical interviews as a 'fear of displeasing' or a fear of incurring error' (Valle & Abranches, 2011, p.84) and which

effectively led to a cessation in the search process. In this case, what makes them stand passive without moving on with their research or breaking up the teacher`s plan can be represented by fear linked to anxiety and/or fear to think differently. However, some students were able to move beyond the "fear" to "breaking up".

"Breaking Up" refers to a change in search direction despite all the dynamics surrounding the classroom practices. Students chose during their research to make movements away from the original subject matter effectively "breaking" the original program or activity proposed by the teacher, sometimes to deepen and complement their knowledge, and other times as a complete break from the subject moving to seek information on other themes readily found on the web, such as football.

"Breaking up" means students divert away from doing exactly the same activity as planned from the teachers. Breaking Up means the student faced the challenge and could mobilize those critical thinking skills (Facione, 2010), bringing a new status, different from the previous when he started the search. The principles of Cybernetics help us understand the man/system interface, whether this system is a machine, a living organism or even a phenomenon. In this section, two cybernetic principles will be used to review the categories initially named as "Fear" and "Breaking Up", these are the Principle of Selective Retention and the Principle of Asymmetric Transitions: Enthropy (Heylighen, 1992).

The fear category reflects the situation in which the self-regulatory system of the classroom causes a repressor impact on the creativity and initiative of young researchers: it shows that, for various reasons, students do not progress in their searches for fear of something or because they dare not move forward beyond their comfort zone. The students reported various reasons for their fears including: fear of breaking the hardware, fear of being discovered (when not following instructions).

Confronting these justifications of 'fear' offered by the students with the Cybernetics' Principle of Selective Retention, it is possible to make another analogy. The principle is simple: "stable settings are maintained, and the unstable are disposed" (Lindgren, 1969). Stability is understood as something that does not change or fade easily and which can be maintained

in the system, whereas instabilities are things that are more easily removed from the same system. Thus, when we cause instability by "disturbing" the system, some subjects who were in category "fear" quickly eliminated the disorder in the system and preserved their original status without reformulation of ideas and without critical thinking or analysing propositions. To remain within the safety margin (or their comfort zone), students who wanted to avoid breaking normal routines and keep to the activity originally proposed, still had to choose between one of the following alternatives with internet research: breaking with the programme established by the teacher and doing their own research; or keeping the teacher's plan and preserving the system. In the case of the category "fear", we see the system stabilizing itself, because students just haven't the wish or courage to break up the rules.

As for the category Breaking, we observed that some students, in particular when faced with a turning point in their evaluation of arguments and proposals after web research, decided to break the system stability and go beyond the norm or the expected in their searches. If we look at the "Principle of Asymmetric Transitions: Enthropy" (Lindgren, 1969), we see that the situation experienced by these students is already recognised within a Cybernetic model: relations in a system should not remain the same for a long time. Thus if critical thinking were to emerge in such a hostile environment it would be necessary to subvert the system order, increasing, consequently, its chaos. Following this observation, within our study group, we found a group of students who, at some point in their search, by way of criticism, made the choice not to follow the initial instructions and questioned the proposed activity with the computer in the classroom, moving beyond what the teacher initially planned and opening up new possibilities of knowledge.

5.2.1 The Cybernetic model for critical thinking

Considering all our observations from the students participating in the OLPC project and in consideration of Cybernetic Science, we realize that there is movement analysis, reflection and judgement of research questions and proposals occurring by the students. However, at any given time, only two paths are possible when we speak of critical thinking:

(1) the maintenance of the system order and hence the lack of questioning and criticism; or (2) the breakdown of order and consequent disruption of this system, with resultant critical thinking skills described by Facione (2000) and which we prefer to call critical thinking itself.

As postulated by Pask (1975), the observer influences processes and outcomes of cybernetic systems through circular and interactive means, and by an approach which he refers to as Conversation Theory. For Pask, interactions are vital for learning. Our studies find that to stimulate critical thinking skills, interaction is also necessary at an initial stage of interaction with digital platforms.

In the second phase of the development of critical thinking skills, there needs to be an initial phase of trial and judgement that mobilizes the student's skills of Interpretation, Analysis and Inference, as proposed by Facione (2000). After this phase, students enter a decisive stage where either (a) the student decides to continue to retention, settling the system, according to the principle of Selective Retention, and opting to eliminate the instability of the system settings (in this case, instability referring to questioning, reasoning, and reworking activities). In the other situation (b), the student follows a different path, increasing the chaos around their own mind and therefore the inquiries and reformulation of ideas. Here, the student has gone through what we call "critical entropy", such that we can observe the deeper critical thinking skills emerging of evaluation, explanation and self-regulation. Consider the proposed model in Figure XX, whose numbers refer to specific action, as described below:
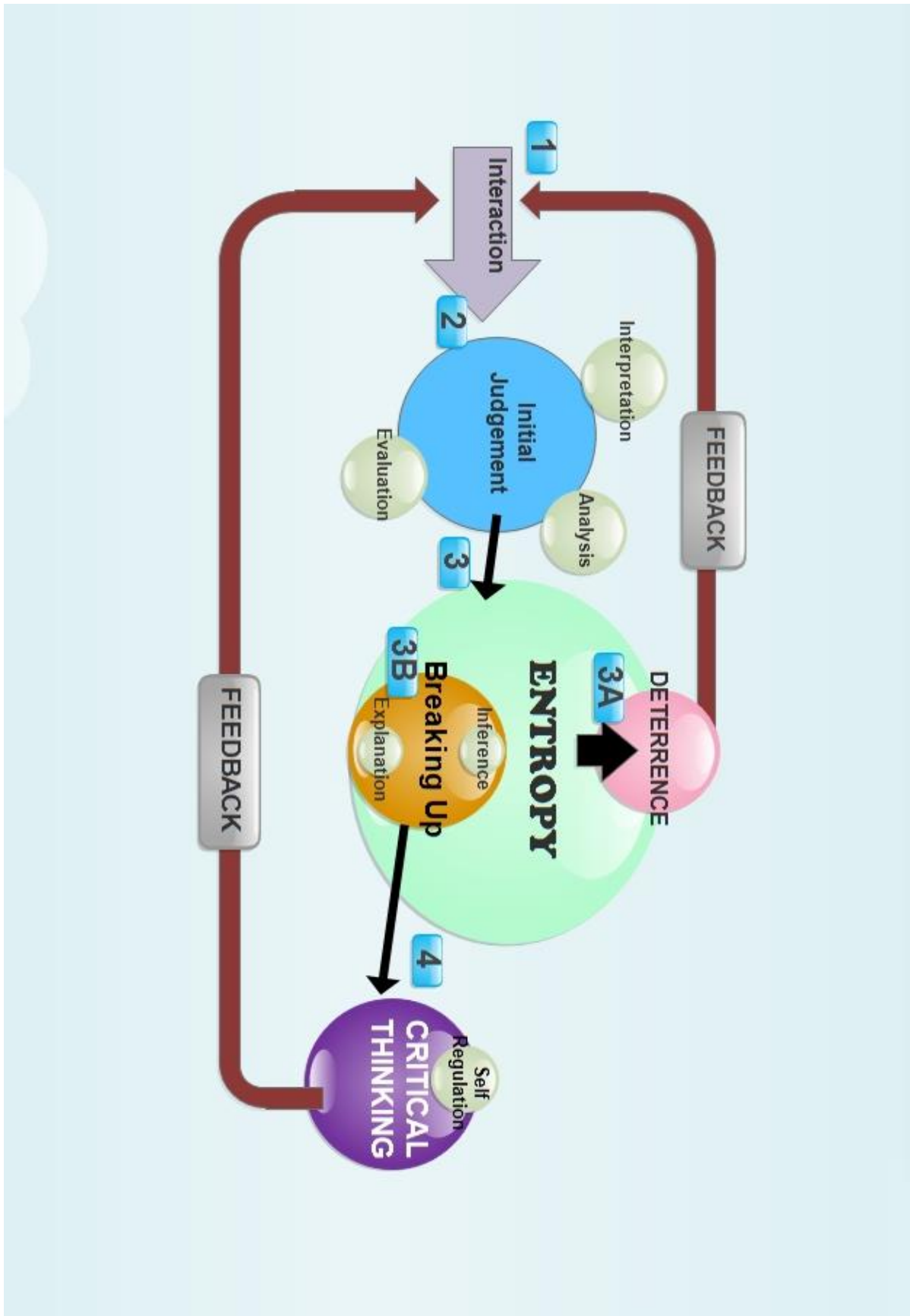
Figure 5.1: The Cybernetics Model of Critical Thinking

We can observe through the presented model that the number 1 movement is located at the Interaction area. As this study focused on interaction with digital technologies, Interaction must be considered from the first contact with the research instrument: the computer or the mobile devices. This interaction brings some new elements and the contact with the proposed research activity protocol (movement 2) triggers the necessity to mobilize the initial skills of critical thinking: Interpretation, Analysis and Evaluation. These abilities may appear simultaneously or sequentially. There are participants who describe their research methods as "multitasked", already interpreting and simultaneously doing analysis assessments based on previous evaluations. After this Initial Judgement in movement 2, it is possible to observe the participant moving around the research question, where all the information and interactions will serve as a tool for the participant to elaborate their first results and search conclusions.

Normally, at schools, the research ends here. The student is asked to search out the main forms of governments, or to solve mathematical exercises, and once he has found the answers, teachers and tutors simply score the exercise. But if the Digital Era brings another individual into the classroom, to whom the main appeal is the authorship and content production through social networks and interactions, it is no longer possible to end the research at this stage, as seen in the topic on the Protocol of as a data collection activity. It is necessary to deepen questions and make scientific research a habit, confronting data and reformulating ideas. This is what was proposed through the activity protocol: the confrontation between various sources and formats of digital files, and the construction of the student's own response.

After the Initial Judgment, the movement **3** will bring the Participant into the Entropy. The nomenclature for the concept of Entropy here is due to the Systems Theory, although it is not the same concept. A general disorganization has been found in the System, and the participant looks for alternatives to balance it. Within the entropic process, there will be two possible paths. In movement **3A**, the participant will tend to simply close his searches and accept results without much deepening, making a move out of the discomfort caused by the disorganization of the System that is his own thinking and the construction of complex concepts, and thus entering the Deterrence phase. It happens because of the student's concerns or Fear of many situations, already mentioned previously. After entering the Deterrence process, the Participant will naturally return to the initial state (feedback), ready

for a new interaction. It is important to point out that nothing will be eliminated once the Participant comes back to the first stage: he/she can always, if appropriately stimulated, cross to the path **3B**, that is Breaking Up.

In the Option **3B**, it is possible to see that the Subject is in the same System disorganization, the Entropy. This participant will attempt to balance his system in the same way, but will use his energy mobilizing other critical thinking skills: Inference and Explanation. The participant will leave the Initial Judgement phase, enter Entropia and mobilize these abilities to answer their concerns, inferring and trying to explain the phenomenon studied. Thus he will bring rupture regarding the former thought, which will be fragmented, in order to find his own answers. When the break up occurs, and the Participant is finally able to exit the Breaking Up phase, and he or she will move to the critical thinking phase. In strong critical thinkers, one last skill is presented, often outside Entropy, and after the Breaking up: the ability to correct their own judgement. Only stronger critical thinkers can do it: recognize what was wrong with their assumptions and reformulate their own thinking. Even those who are not able to mobilize the self-regulation ability, must be considered critical thinkers, and all who have come through the Breaking Up movement, will return to the initial status of interaction via Feedback. Again, nothing is closed, all the possibilities are open while the interaction can be exercised.

5.2.2 Considerations about the model and artificial intelligence

There is an ongoing idea in Modernity that Human thinking is logical and is usually trying to keep distance from everything that contradict the patterns of logic. The formal logic, the one known as the classical form of representation of knowledge about the world: is a systematization from Aristotle that had an important influence on philosophy and this type of logic was adopted as a model of human reasoning (Johnson-Laird et al, 2015). According to current ideas, it is possible to observe the Human thinking inside the so-called positivist and reductionist paradigm. Reductionist and positivist because it is generically defined as the expression of a classical approach proposed by Descartes that has the analytical nature of thinking the entire object, and then dividing this object into parts, and then concentrating on

each part separately (Joullié, 2016).

It is often said that the purpose of science is the classification and prediction of observed results, and that characteristic is distinctive of modern science as in mathematics and experimental method (Forbes, 2013). This is correct as a first approximation, but we need to consider that the experiments are used not only to discover new facts, but also to reveal the detailed structure of the preceding facts. The laws and descriptions of Aristotelian Science were to account for observationally identifiable traits exactly as they appeared to the observer.

The laws of physics, in their traditional formulation, describe an idealized world, a stable world, not the unstable, evolutionary world in which we live. Once there is a principle or law, it can be applied in all circumstances (stability); all bias and variations would be considered only as occasional circumstances (instabilities). The main point is to consider whenever is possible observe a world free of interferences and instability. This view compels us to reconsider the validity of fundamental laws, classical and quantum. At first, our refusal to trivialize irreversibility is based on the fact that, even in physics, irreversibility can no longer be associated only with an increase in disorder. Quite the contrary, recent developments in physics and non-equilibrium chemistry show that the arrow of time can be a source of order. Irreversibility leads both to disorder and order. Far from balance, the constructive role of irreversibility becomes even more striking. It creates new forms of coherence there, insofar as life is possible only in a universe far from equilibrium (Prigogine, 1999).

Reinforcing Prigogine's thinking, Morin (2005) states the need for a method that distinguishes, but does not separate and dissociate, and that knows how to promote communication of what is distinct. Concealing both social and biological dimension is an urgency for sciences, while this method will consider the multiple character of social reality.

To consider a space that must be enlarged, Morin's (2005) thoughts emphasize the existence of certain spirits who do not want to realize that, contrary to the classic dogma of separation between science and philosophy, the advanced sciences of this century all met and rekindled the fundamental philosophical questions. The greatest scientists since Einstein, Bohr and Heisenberg have turned into philosophers as though rejected (Teixeira, 2008) by contemporary science, dualism still seems to be the horizon of our culture.

5.2.3 Complexity and Brain

It is important to note that in Western culture, we are conditioned to think a linear way (Wood, 1999). It is important to question whether such a form of evaluation can actually be applied in the study of the human brain, the hierarchically responding organ, as the seat of man's most elaborate behaviours. The answer to such questioning would probably be no.

Damásio (1996) expresses his difficulty in accepting that scientific results, especially in neurobiology, are more than provisional approaches to be savoured for a while and abandoned as soon as better explanations emerge. For scepticism concerning the current attainment of science, especially in regard to the mind, involves no less enthusiasm than attempting to improve interim approximations.

The brain and mind complex is an open system, which has its plasticity (with great behavioural variation) and which deals with precision, ambiguity, completeness, disorder and therefore has to develop strategies for its organization. While considering the existence of systems, the reductionist method loses its acuity, requiring a holistic way to apply the analysis. One can understand such essentialities in Luria's words:

> Human mental processes are complex functional systems and they are not -located in narrow and circumscribed areas of the brain, but occur through the participation of groups of brain structures operating in concert, each of which competes with its own particular contribution to the arrangement of this functional system (1973, p.23)

Damásio (1996) reinforces Luria's ideas by defending the notion that no single mechanism explains consciousness in the brain, no device, no region, characteristic or trick can produce it unaided, just as a symphony cannot be played by a single musician, and not even by a few. Many are needed. The contribution of each is important. But only the whole produces the result that we seek to explain. Instead of relying on unique specialized areas (Nicolelis, 2015), the human brain chooses to perform all its arduous tasks through the collective work of large populations of neurons distributed across multiple brain regions, also called neural grids.

Perhaps the complexity of the human mind is such that the solution to the problem can never be known because of our intrinsic limitations. Perhaps we should not even consider

that there is a problem, but instead talk about a mystery, distinguishing between the issues that can be adequately addressed by science and those that are likely to deceive us all the time (Damasio, 1996, p.19).

In Nicolelis's Relativistic Brain (2011), part of our neglect to explore the complexity of the brain can also be explained by the tremendous experimental difficulties involved in simultaneously recording the electrical signals produced by large groups of individual neurons distributed across multiple brain regions.

The human brain can be considered as a super system. Each system consists of a complex interconnection of small, but microscopic, cortical regions and subcortical nuclei, which in turn are made up of microscopic local circuits, formed by neurons, all linked by synapses. The human brain reveals itself in such a way, a relativistic sculptor. It is a skilled artisan who lightly fuses neural space and time into an organic continuum. It allows him to create everything we are capable of seeing and feeling as a reality, including our own sense of being and wellbeing (Nicolelis, 2011).

According to Forbes (2013), it is up to the brain to organize a system of communication of thousands of data, so that adaptive responses integrate knowledge repertoires of individuals. From hundreds of billions of neurons (Nicolelis, 2011) and their connections, which together provide physiological changes from millisecond to millisecond, the human brain conceives an archetypal model of a complex system.

The study of cognition (Cecconi, 2016) presents this new dimension of complexity, in conceiving the brain and its functioning, in a new scientific dimension based on cybernetic theories. In theories of information and communication, cognition is, before everything, a highly organized complexity. To Morin (2005) thought has the capacity to transform the conditions of thought by not being dissociated by incongruity or antagonism, considering that such dissociation evidently extinguishes the contradiction. Of course, integrating it into a set in which it continues to grow also acquires constructive potentiality.

The applicability of Neuropsychology is the demonstration that knowledge does not materialize under the exclusive aegis of a given rationality or field of knowledge, on the contrary, **"knowing"** (Rode, 2017) is based on several other plans. Other glances and the circularity that is affected by the existence and effectiveness of scientific dogmas, whether linear or systemic, as long as they can explain or understand the true nature of phenomena.

The artificial intelligence developers must consider other areas of knowledge

contribution, specifically that of neuroscience. The proposed model for critical thinking was only possible because scientists who were involved in the research considered the human thinking as a complex system. If artificial intelligence developers want to develop an intelligence similar to human brain, they must consider contributions from neuro-cognition fields. The Digital Age brings a necessity of a holistic view, a different approach to the object or the phenomenon.

Summary

The principles of Cybernetics may be helpful to understand the man/system interface, whether this system is a machine, a living organism or even a phenomenon. In this section, two cybernetic principles have been used to propose the theory and validate a model that can explain the critical thinking phenomena stimulated by digital technologies; these are the Principle of Selective Retention and the Principle of Asymmetric Transitions: Entropy (Heylighen, 2007). This chapter also explained the Model developed during this research, which considered the Human Critical Thinking process as a complex phenomenon and the surroundings to be considered while explaining the phenomenon, also pointing to some issues to be observed from artificial intelligence developers.

Chapter 6

Conclusions, Findings and Implications

Chapter 6: Conclusions, Findings and Implications

6.1 Chapter Overview

This chapter concludes the research conducted and reported in chapters 4 and 5. We evaluate the work under a holistic perception and summarise this Research, presenting the reader with a summary of the work. Also presented is a critical consideration of the research contributions, and recommendations of future work.

This conclusion summarises how we investigated critical thinking and their construction while following a Research activity protocol online. In Chapter 2, we had the Literature Review, developing the views and concepts concerned to the Cybercultural society, the philosophical framework and the necessity of developing a critical a pedagogy at schools, aiming critical thinking. The research aim and objectives have been presented in Chapter 1, while the Methodology has been defined however, we discussed the research design in Chapter 3. In Chapter 4, we presented the participants, results and we discussed the outcomes of the data research. In Chapter 5, we presented the development and validation of the model, while reflecting about the interpretations of the methodological journeys, as we concluded the proposed model was a good representation of the cognitive process to build up Critical Thinking. We suggested the Critical Thinking as a system, considering the elements that have been directly associated to that system and using Cybernetics to guide the journey through understanding. In our first study, we tested the Pedagogical approach for Critical Thinking understanding. In the second study, we tested the Cybernetics understanding for some phenomena, successfully applying these principles for Critical Thinking. The outcomes for this experiment have been presented as a Cybernetics Model for Critical Thinking, in Chapter 5. The final chapter in the thesis concludes the research conducted and reported in chapters 4 and 5. One key aim here is to reflect on the theory that has been developed and also consider how the work can be developed from here.

As such, the chapter begins with a detailed summary of the work described in the thesis. There is then a critical analysis of the approach and the theory developed. The contributions from the work are then described, followed by some suggestions for further work. The chapter finishes with a conclusion.

6.2 Summary and Key Findings

This thesis is presented in six chapters. The first chapter provides an overview of the research problem. We explained why Critical Thinking is an essential ability for the citizen in the Digital Age, where the availability of knowledge in this 'information age' brings the need of evaluating information, frequently discarding what is not relevant. We also argued that it is necessary to know how critical Thinking is fostered in order to develop suitable approaches to develop these skills. This work aimed to understand school's challenge on fostering Critical Thinking, how Cybernetics principles might help schools to adapt to Digital Age. The first chapter also presented the main objectives of this research and the research questions that this research aimed to answer.

Chapter 2 presents the literature review for critical thinking challenges in the Digital age, and how they are related with the lack of stimulus for fostering critical thinking at schools. In a closer look, we discussed how the social Habitus (Bourdieu) interferes on critical thinking shaping. We also suggested the Constructivist approach would be the best option for critical thinking construction. We observed this approach could be operationalized by one research protocol activity. We have presented the general aspects of Cybernetics proposals and the main principles that helped us to understand the critical thinking construction: The Principle of Selective Retention and the Principle of Asymmetric Transitions: Entropy (Heylighen, 1992). These two principles have been used to build the model, because they describe exactly what was happening inside the critical thinking system. We also established critical thinking understandings presented in the Statement of Expert Consensus from American Philosophical Association (APA), published by Facione (1990, 2015). At the end of the chapter, we presented research questions.

Chapter 3 presents an overview of the research methodology and data collection procedures adopted. This research is a result of two large studies: my Master's research, which we decided to name Pilot Study, and the Main Study, collected during this PhD. Both studies had extensive literature review in relevant areas, helped the researcher in identifying research gaps and in developing the conceptual framework, especially while considering the possibility of the studies phenomena explanation being supported from Cybernetics science.

In both stages, I decided to use the same methods and techniques to avoid bias concerning the data collection instruments: I needed open answers that could be reassessed later, during the clinical interview. Therefore, I proposed an online activity, where children would research some subject and would build their own concept of a myth, at the end. This format allowed a rich data collection result, which has been analysed using Content Analysis technique (Bardin). Because of the methodological rigour applied on these analysis following Bardin's methods, we could better visualise the stages described on APA's consensus documents and have a better picture of the elements that have not been originally classified.

I also presented at this chapter, the data collection procedures and the data analysis instruments. We decided to assess school procedures for activities online with a simple conversation via Skype with two teachers and the Head of School. After that, we collected valuable information about participants and developed the data collection activity: a protocol to be executed online. This chapter outlines the development of these activities and necessary procedures to be followed at the data collection.

In Chapter 4, we describe the participants and the social reality surrounding them. The data collection was performed in a poor neighbourhood in Brazil, where the lack of resources is an important point to be considered, because it can bring us some unwanted bias: a hungry child will probably not have enough energy to establish complex thoughts while searching. We had to be careful with that. We selected fifty children for the activity and interview, the data collection has been completed with all of them.

The results have been described at Chapter 4, where I recognize the research protocol activity has been completed without many difficulties, but the clinical interview revealed a bit complicated for some of them. Answering questions about their thoughts while they were searching online made some children feel uncomfortable. While working at the pre-analysis, we realised there was ten interviews that would not give us any material for analysis. They just had evasive answers such as "I don't remember...", "I don't want to talk about it" or just "can I come back to my classroom, please?". Because of this, we decided not use this material at the analysis. After the pre selection step, we worked with the data analysis software Atlas Ti, to perform content analysis. The software helps to organize all data, generating the final document knows as "Atlas Network", producing one network for each category selected *a priori*: interpretation, analysis, evaluation, inference, explanation and self-regulation. We also produced two network for the categories a posteriori: *breaking up* (we called it Entropy, later)

and deterrence. This step allowed us to better visualise the whole data corpus, for better understanding of the phenomena involved.

In Chapter 5, we brought the Cybernetic Model for Critical Thinking. Bringing all data in a proposed visual model was the next step. Particularly, I had some difficulties with the operational part to bring a suitable model that could bring what we have seen during the research. How to represent the thinking movements of build/rebuild of concepts was something that required lots of research in many models proposed from Cybernetics science. From them, we realised that arrows can represent movements, for example. In another moment, we found thinking could be expressed with circles without any damage to the general idea. We observed it is possible to consider the research was well performed in terms of reaching the students' critical thinking in this digital reality. The approach that included an online research activity and a clinical interview allowed participants to develop their research trajectory and allowed us to reach the cognitive level of participants, which was what we needed. It was also a more specific goal to look closely at these steps of school web search, which was fully achieved by capturing the computer record of the history of the internet browser. The steps followed in this study were satisfactory to achieve the main purpose. It was possible to clearly perceive the critical thinking abilities presented by the children, tracing their search paths on the web, observing the development of their thinking and the cognitive criticality skills mobilized. The description of this trajectory by these students, although long and slow, was quite rich and productive.

6.3 Research Conclusion

The main research questions were: Why is the level of criticism and research production - even in schools - still so weak? How is critical thinking fostered/formed while using digital devices at schools? The literature review helped to identify some of challenges. However, only some doubts have been answered from the literature point of view. We had to request the help from other researches and professionals linked to Cybernetics in other areas to have a better understanding because the question involved many agents: participants, schools, society. One of our conclusions is that simply adapting school facilities for the use of Internet with students will not guarantee quality teaching. Training for

educators is needed to really achieve better goals and to include a broader vision for teaching and learning at schools is necessary. Teachers also need to learn how to research, how to accept and reject information and to elaborate their own concepts. We need to think about the Digital World, the world where fake news can win the elections and people can believe the Earth can be flat if we do not stimulate critical thinking. Facing this reality can be complicated to some governments because it involves investment. However, it is necessary to think about the third millennium society.

In order to answer the research question, we needed to know a bit more about schools reality. We aimed to know from the bigger (school) to the smaller structure (children's brains). We are aware that is not possible to know all the elements that may interfere in that complex structure, but we decided to do the best to know the structure in order to better answering the problem. However, we had only two weeks at school, which brought us some creative solutions like meeting the school staff via Skype. From there, we could realise the teacher authority is exactly as in any other school, which brings us to questioning the traditional model for teaching and learning around the world. We always questioned why all professions changed with technologies, they adapted and improved, but the school refuses to accept and welcome technologies and change with them.

Other few times I have seen teachers exemplifying their "good" uses for web platforms and online activities. They describe a certain platform they use online to put their mathematics exercises and the children solve their exercises there. In addition, a platform where they can search for some topic (World War I, for example) and answer some exercises as well. Far from good examples of the use of technologies to foster critical thinking or even a good lesson, they just reproduce technicist teaching online. Being digitally included means using digital technologies to **produce** content. More than a reproducer, the student needs to be an author in Digital Age. This authorship should begin at schools, in order to make children digitally included.

When we talk about digitally inclusion, we need to know inclusion is a complex phenomenon in the digital age. We can easily find examples of citizens who have digital devices in their hands but they don't really know how to deal with the massive information they have available. As said from Alvin Toffler: "The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn." It is an urgent task to prepare students in general to think critically, to avoid a chaotic society as a

product of the naive behaviour facing social media. In our main study, we found that the students already had good web management and selected their sources faster and more accurately. Some even said they had other sites where they liked to collect information other than what the teacher was instructing. This shows that our participants, when submitted to the virtual environments, developed some skills and some understanding about Internet searches. From the pedagogical approach we have in this research, we believe the creative activities online should be stimulated at schools. However, we know creative technology at schools is rare to observe.

Some students stated that they liked to search for videos and songs about the proposed themes, and this allowed them go deeper in their research, bringing more critical attitude towards the proposed research themes. It worked like a situation that they could see anything as part of their results, but not everything should work. So they reported they have more responsibility on what they write as result of their search. I find this specially curious, once in regular search at school, the videos and music should not be considered "research results" according to the teacher, thus making discouraged students look for copy-and-paste as an alternative and as a form of protest, even if it is unconscious and incipient. In this case, would advanced critical thinking be connected to the web environment or would they just be isolated cases? In conclusion, we can state that, although the research proposed by the teachers ends in the data collection phase, the students showed signs of critical thinking. From students, there is no awareness of "being critical" but the skills and competencies are already there.

It is also important to emphasize that the students who went beyond the proposed searches, wanting to deepen and discuss their knowledge, did it alone without the help of someone. The school did not foresee, by its very structure and configuration, how to deal with groups of more curious students or more researchers than usual. The classic groups of teachers hoping to deal with the classical student groups in the digital era in general form schools.

Before the data collection, we have been concerned if students would behave timidly in the face of Internet searches, not daring much in their research, thus inhibiting the possibilities for the emergence of critical thinking and related skills. However, as a scientist, I should report any findings. According to previous studies (Valle & Abranches, 2011), it was observed these situations could happen more frequently than supposed. The approach to

avoid this bias was telling students this would be an activity that would not involve any kind of marks. Once the students were alone with me in the computer lab, I found it appropriated to explain the activity and leave the children alone to complete the activity protocol. It was observed, even though, that the behaviour of children with some kind of concern or fear was reflected in the results, which confirms our theory proposed in the model: this behaviour is more than a habit, it is the true nature of the Deterrence level.

Despite the fact there was a timid behaviour from some children, this was not a predominance in the data collection, since the students mostly succeeded in completing the research protocol, even getting out of the usual schedule by the activity, tracing their own path according to their curiosity or need. More evidence was found of elements of critical thinking than was initially expected, because the students had greater autonomy in order to complete their searches. The lack of a questioning movement and non-present investigation extinguished the possibilities of mobilizing the cognitive abilities of critical thinking, since it was proposed initially in this study that the research and analysis movement would have these abilities as a result.

In addition, the timid behaviour from some students while searching is because the search in the Internet ends in the data collection phase, and is not discussed, re-elaborated and restated by the teacher and students. For a few years, educators have seen the most varied discussions on how to optimize learning in the school space. Continuous training programs, discussion on assessment, literacy, artwork, and continuing student promotion are mentioned, as well as how to use technology to do better instruction. Motivation alone does not produce change (Gershwin, 1994). It is imperative that teachers and administrators understand that schools cannot be static institutions.

Some of the research participants wished to know the correct version for the Minotaur myth. Because the data collection was performed at school, they expected that someone would give them the answer on what is "correct" or "incorrect", at the end of the research. The revealing surprise was when I had to inform them there was no right answer for the real version of the Minotaur Myth. They had to choose, accordingly to their findings, which would be the best version or they could create another version for the myth, but it was not necessary. The proposed research protocol ended at the point the participants choose their version for the myth, so because of this I decided not evaluate the versions they sent to me by email: their own writing story about the Minotaur myth. I received eight stories from

research participants, all of them very rich in details and bringing new elements for the Minotaur. The decision for not using them as part of the data corpus was because in this research, we are interested on the process, more than in the results of their research. Ability to resize and redirect their searches would be something expected of a critical thinker of the Digital Age. However, we know that the skills demonstrated here are still incipient, even if they are aimed at deepening the content. The judgment that these students presented, for example, from certain sources of information shows that they already perceive, albeit intuitively, the importance of not giving up effort in a web search. It would be interesting, for future works, a combined data corpus with results plus processes, to check effectiveness of critical thinking on building up complex knowledge.

Some participants reported that they have not finished the searches because of lack of time, which leads us to conclude that it is of superior importance to rethink the time of activities proposed in the school. As is known from most educational theoretical approaches, especially constructivists, each person has an individual time to perform activities, and that time varies. Children can have access at home to digital platforms that contemplate all educational content, involving the production of individual content, resulting in digital or media files, texts, photos, blog, video logs because of learning. It would be more effective to consider a learner that can produce his own YouTube content expressing his opinion about the events concerning Black Death than simply applying a cold exam to check his ability to retain facts in his memory.

The main goal within this research was to build a model for critical thinking in the digital age. We do not know if the models considering cognitive behaviour using digital devices can be different from those that have been proposed not considering specifically those technologies. However, we found with Cybernetics the answers we have been looking for. We recognize it is not usual to consider human cognition and all processes related to it as an open system. We found with the Entropy principle, from the Information Theory usage, an explanation for the phenomena. We "borrowed" the term name because it contains exactly the idea expressed at Chapter 5 for the disorganization of systems. Second, among all the processes to which information can be submitted, one has a prominent place. It is feedback, which is responsible for the existence of intelligence and purpose. Through it, a system is capable of establishing a relation of self to itself and to that which is external to it not restricted to simple action and reaction. By using the product of its own actions as input

information guiding the following actions, a mechanical or organic system exhibits intelligent behaviour. Instead of simply responding in a standard way to stimuli, it is able to ponder the "value" of the information received, deciding in function of what kind of responsive actions already known to take, or to seek new response patterns (as in the case of the homeostat). By controlling its actions for information received rather than submitting itself without mediation to the action of efficient causes, a system exhibits goal-oriented behaviour: by allowing causal power only to stimuli that are messages (information in an appropriate code), the system is capable to respond only to stimuli related to the "goal" that moves it. If we consider our proposed model, is possible to see the Feedback of all actions regarding critical thinking because the system always feeds itself: the thinker never stops to think. The model proposed is also based on feedback, because this mechanism guarantees the existence of communication in the precise and true sense of the term in the system. We can call it a two-way relationship between inner and outer, between action and reaction, stimulus and response, this is the mechanism allowing the existence of several subsystems, several semi-autonomous and interconnected levels of operation in a single machine-organism. Therefore, feedback is the actual control in operation.

Cybernetics science was decisive for us, to complete this study. The contributions and concepts brought from this field allowed us to know what was happening inside the brain and cognition, while the participants were building their critical thinking. As stated above, we used Entropy to refer to the increase of chaos and disorganisation inside cognition, that is in an information context rather than the traditional energy context. The same consideration can be applied with the phenomena we called "Deterrence", where the Cybernetics principle states, "stable settings are maintained, and the unstable are disposed". It is very important understand the Cybernetics role in this research, because we do not intend to be technicists in expressing our results.

The proposed model must be considered as presented in its Chapter: when entering the initial process of critical thinking, the participant mobilizes skills. These abilities are arranged in a circular way because, as we previously mentioned, they can be manifested in a non-sequential way, according to the presented data. The boundaries of the circles consider the phase in which the Participant is, so it was not left open, respecting the current moment. The arrows would be movements: thoughts in motion, moving on, moving to something later, not stagnant, arising elements of Connectivity and Chaos Theory. This moving thinking can

lead to critical thinking (Breaking up) or to the same initial situation (Deterrence). Upon reflection, I concluded that this same model can be applied to learning processes in general but it is not a certainty. It must be remembered that this model cannot and should not be considered as the only truly applicable one, since we are within a constructivist dialectic approach.

As stated in this study, Critical Thinking is a result of a movement of research and deepening of concepts by the participants. To understand this study it is necessary to read the document and understand the concepts of Literature Review, where the following concepts are listed: Pierre Bourdieu's Habitus; Enlightenment, from Kant; Power, from Foucault. Without understanding these concepts well, there is no way to understand this study and one may incur the error of trying to take it to a rigid Behaviourist approach where it would be completely useless.

Freedom, for Freire (1996), begins when we recognize a system of relations of oppression, and our own place in that system. The task of critical pedagogy is to bring members of all groups (oppressed or not) to a critical awareness of their situation as the starting point of their liberating praxis. Changing the minds and subsequent concrete actions are linked, for this kind of pedagogy, so the greatest barrier to the only possibility of liberation is a belief, rooted in the inevitability and necessity of an unfair status quo. It would also be necessary for a social question that the critical citizens' conscience could be stimulated and the students' efforts in this sense could be equally well received. However, some of our categories reflect the situation in which the self-regulatory system of the classroom still provides a repressive impact on the creativity and initiative of these young researchers: the "deterrence" category shows that for various reasons students did not progress, mostly related of the fear of something. It was reported that students feared that they would not dare to go further much more in their research. When questioned, the answers were the most varied, related to fear of having a low mark for their exams. This "fear" shows that we still need to open up schools to a broader vision of education and equality, with no need of old methods that will not work for the digital age.

At the end of this Research, we could clearly see how important is to invest in school's comprehension about changes in Digital Age. The student profile has changed, and the society demands another necessity: the critical thinker. With traditional approaches, we observed it would not be possible to foster critical thinking in students at the same time it will not make

teacher's lives easier. Once we already know the third millennium citizen needs to be a critical thinker in order to succeed, is time to think about how to make it happen at schools.

Summarising the findings of the two experiments performed for the proposed research objectives, is possible to confirm that secondary school students are willing to have more opportunities to learn and research using internet as learning option. On the opposite side of what teachers and schools think they would do, is possible observe they really would like to produce their own content and show their findings to the world.

When we look at the model presented in this research, it is necessary to recognize it was built over a complex database, knowing there is not easy road to reach this kind of phenomena. However, we consider it was a satisfactory result and after all the effort, the model was finalised with all the elements it should present: skills, transition moments, phases, all explained and connected with Cybernetics principles, with some elements of Chaos and Connectivity. We have to recognize that was not an easy task.

6.4. Research Contributions

This work has a significant contribution to the existing critical thinking literature while it goes beyond, proposing a holistic approach that includes Cybernetics and Cognition. While located in between those three areas, researches from all of them could take advantage of this approach. The developed concepts of "Entropy", "Deterrence", and the Model itself can help assessing learning and cognition in another dimension.

We proposed the concept of Entropy to critical thinking (see Chapter 5) fostered from a large literature review that involved Philosophy, Sociology, Education and Cybernetics. The concept will be helpful to researcher who wants to dedicate their project to cognitive phenomena, or to Human-machine interaction. Similarly, the concept of Deterrence can equally be used for areas where cognition, education society and Cybernetics can be helpful.

Like Cybernetics' original scientists, we believe the same idea at this research can be used and adapted to most knowledge areas. The results presented involving school search and activities can be useful for schools and companies that aim to provide learning for life quality. This study's results can be helpful also for comparing models, or how to frame a model

from a complex situation. The research technique can be adapted for various spheres, especially those involving online behaviour, accessing and development of online platforms from public, questioning and absorbing influence online, testing platforms, cognition, public policies, Human-computing Interaction, Education. As we could observe, the online behaviour changes and people seem to be different while using computers to do their activities.

The debate we proposed considering effective use of digital technologies at schools to foster critical thinking is a meaningful academic contribution. Some professionals from education area would say technology cannot foster critical thinking, but we proved this is exactly the opposite. This research provides a debate about the situations faced from Education at third millennium, emphasizing the cognitive model for critical thinking, while consider interactivity aspects. Some learning systems might be interested in our results because it will bring a larger picture of what to consider when aiming engaging digital activities and resources.

The most relevant contribution is the cybernetics model for critical thinking. The learning institutions can use the model to apply as a guidance at schools aiming a better student performance. Organisations probably would benefit from the model if applied at the company, aiming a better quality of services from employees, while it would be helpful to identify liabilities and changes that can put into practice to improve the quality of services.

6.5. Further Work

Our study, as already stated, was carried out at a Public School in Brazil, using digital devices. We know the Human Cognition is similar in different cultures, but cultural elements could interfere at the result, acting as a bias. We recommend new studies to complement and elucidate points that may have been obscure in this study. Possible future work may be:

1) Comparative analysis, repeating the same research technique in public schools in the UK, with students at the same age on this study. The academic relevance of this new study, a comparative analysis, will allow us to check both results and amplify the outcome of both researches for the validation of the Model for Critical Thinking in the Digital Age in a broader way.

2) Expanded study with University students, comparing the construction of their critical thinking while facing complex data online. For this study, however, the attention on the online activity proposed by the Researcher for a data collection needs to be extreme, observing the directions of a research protocol proposal by Demo (2011).

3) Comparative analysis between the model proposed by this study and other models proposed for Human Critical Thinking, being fundamental to compare, in this study, the theoretical bases that support all models.

4) Case study with school communities where is possible to find the highest amount of critical thinkers, to know educational approaches that may support critical thinking at schools. Building a database with these schools will allow us evaluate the best pedagogical approaches and will be a good reference for well-succeeded school experiences for critical thinking, using them as model-schools.

5) In our study, we just checked processes (how critical thinking is formed). A larger study that can consider the results of the research protocol on internet would be advisable. Checking the final product of their research to observe improved knowledge areas after the intervention to evaluate effectiveness of critical thinking on building up complex knowledge.

6) Comparative analysis between two populations: the first, critical thinkers from digital age and the second, critical thinkers from previous generations. This study will be essential to delimit the extension as technologies favourable to the emergence of critical thinking.

7) A longitudinal study approaching critical thinking under genders perspective. We found, roughly, some discrepancies between genders and critical thinking; however, we could not dedicate a section for this subject within this study.

8) After considering some of the data collected, specially the evasive answers of the students while avoiding to explain some of their cognitive constructions, is recommended a new data collection aiming only to explain and clarify this phenomenon. This might be a particularity of "deterrence" category or another phenomenon associated to the critical Thinking, but it is not clear at the moment.

6.6 Conclusions

This study aimed to explain how critical thinking was fostered by digital technologies in the Digital Age. For this, we considered the web-search trajectory of 39 students and a clinical interview to support reaching the cognitive level. The findings brought a clear picture of what happens into the complex structure that is the human cognition while learning and building concepts. The data *corpus* was complex, formed by questionnaires, web-search histories, clinical interviews and notes made during the preparation for the data collection. Because of this, we had an extensive data corpus after the data analysis. We proposed the model supported by Cybernetics science, which has been successful in keeping the integrity of the material collected expressed in the Model.

The reflections proposed have been made to provoke discomfort and stimulate the thinking about the topics covered in this study. Someone could point out that, according to our proposed model, "everybody can be considered as a Critical Thinker", because at some point they will deepen their research on the internet concerning some kind of subject. I must also remind the reader that this study is concerned with the research that happens inside school, most precisely while students use the internet to search about any subject proposed in the classroom. It is about the quality of approach from teachers, and how effective their stimuli are to make the Critical Thinking rise. If we consider other environments outside school, is very likely that children are going deeper in their favourite subjects on Worldwide Web. The Digital Age requires a prepared citizen with awareness, good disposition, critical, able to learn and learn again.

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Appendix 1: Example of Clinical Interview Transcript in Progress

File — Home — Search Project — Analyze — Import & Export — Tools & Support

criticalThinking28May - ATLAS.ti

Create Free Quotation | Open Coding | Code In Vivo Coding | List Coding | Quick Coding | Auto Coding | Focus Group Coding

Coding

Rename Delete | Unlink | Flip Link | Relation | Comment | Margin Entities

Quotation

Document | Tools | View

Word Cloud | Word List | Search Document

Explore & Analyze

D 14: Cl6

2. Briefly summarize, with your words, the story of the Minotaur.

The Minotaur was born of a woman is half bull half man is one of the most known characters of Greek mythology destroying a maze by the King who had the Minotaur get stuck during chick who was considered a very dangerous creature of the year sent 14 people Seven Women and seven Men to satiate that Minotaur who devoured them all that a woman I do not remember her name varying the will was there to meet Auro and he fell in love with her and She helped him out of the maze and so his story follows   ◇ Analysis

3. What did you like the most in the story of the Minotaur? Because?

4. Did you find the information easily? As?

It was easy to find had on the site there that said the same thing completely different from the stories I read we bought one site with the other to see if it was even history researched how it was how he was half man half bull vivi we discovered that it has Several versions of it in a way it in another thing has a website that says another   14···· ◇ Explanation | ◇ Self regulation | ◇ Breaking Up | Entropy | 14···· ◇ Inference

5. When you searched the information on the internet, how did you decide which were the most important?   ◇ Irrelevance

Knowing the story we have to know the origin of the Minotaur from whom he was born because we think he is a monster half man half bull he was born of a magic and we tried to highlight the most important where he was where he lived And why this Christmas name?   ◇ Explanation | ◇ Inference

We decided to always put the first search engine option that was usually better

6. Do you think the information you have found is reliable? Because?

They are reliable because when we look at the text we look underneath who was the one who wrote the text if the source is reliable that was that launched according to historical books researching information and putting on the internet does not have information that are too silly more stinging then We can not trust   ◇ Explanation | ◇ Inference | ◇ Self regulation | ◇ Irrelevance | ◇ Inference

7. Is there a relation between the myth of the Minotaur and other Greek myths? If so, which ones?   ◇ Explanation

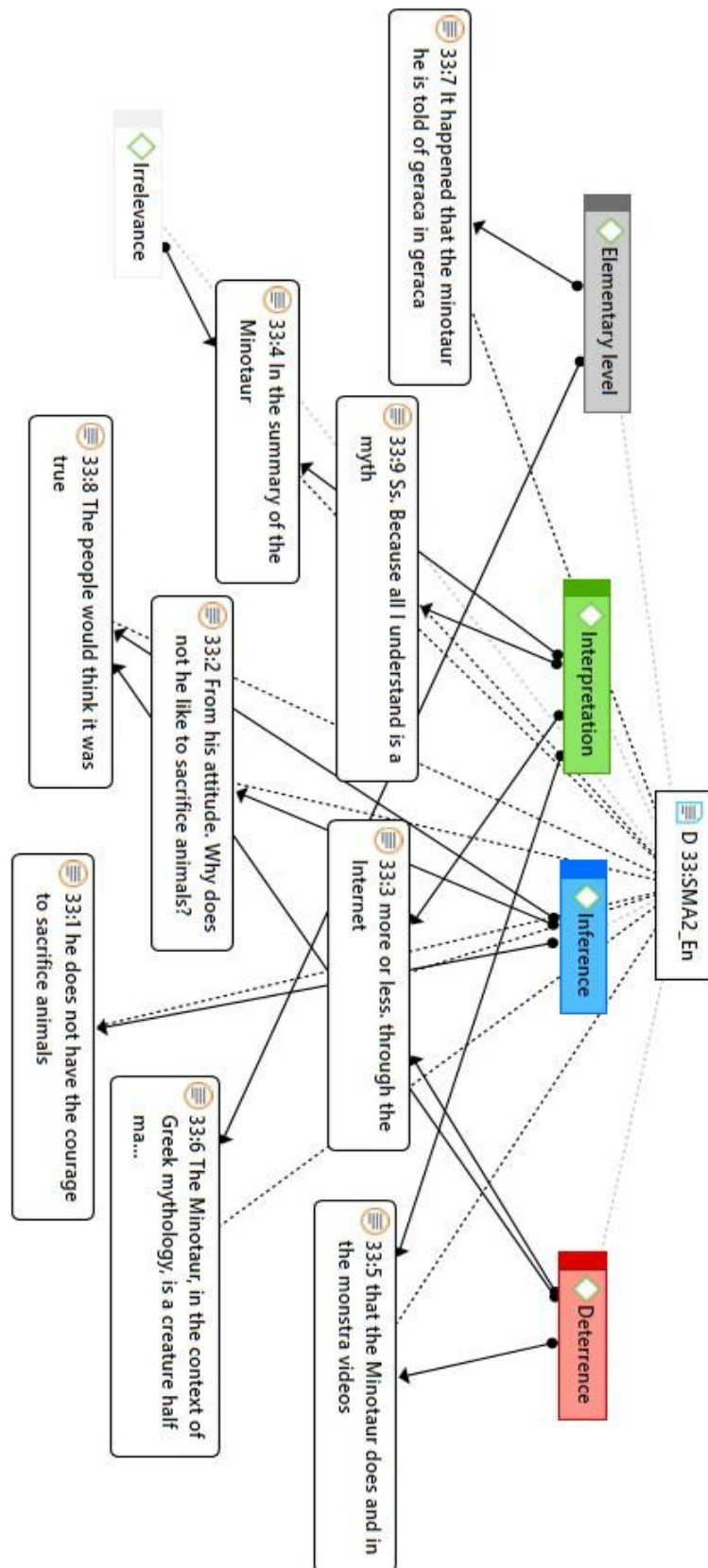Student 2 correct not Poseidon not everything to him among other unrelated stories also has an I am from God of the sun at sea and have

ATLAS.ti   150%

Appendix 2: Example for Critical Thinking phases in one participant (with Breaking Up)
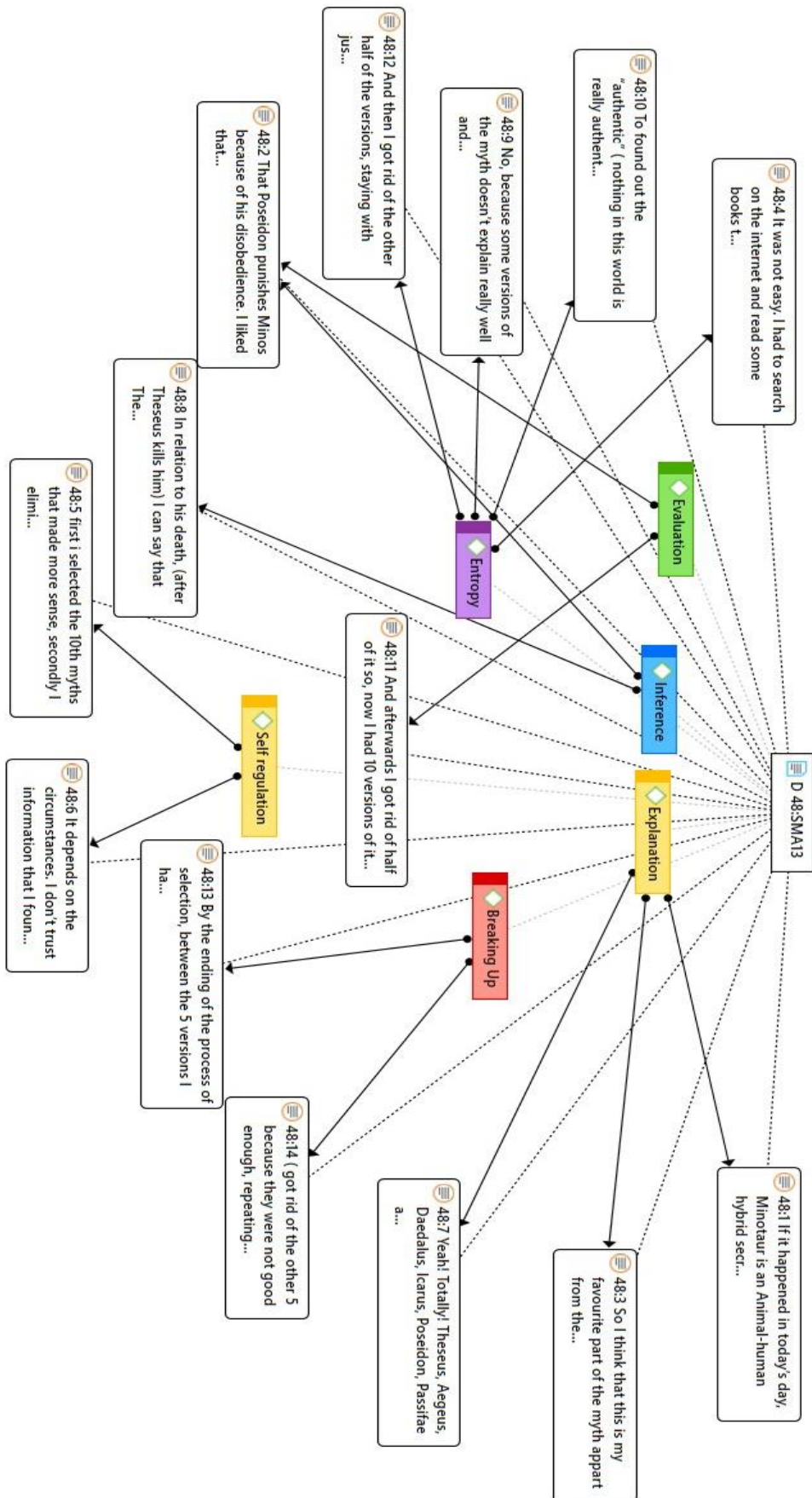
Appendix 3: Example for Critical Thinking phases in one participant (with Deterrence)

Appendix Four: Information Sheet for parents

Folha de Informacao para pais e responsaveis:

Projeto de Pesquisa: A CONSTRUÇÃO DO PENSAMENTO CRÍTICO COM O USO DE TECNOLOGIA DIGITAL DISPOSITIVOS: UMA TEORIA PROPOSTA PELA CIBERNÉTICA CIÊNCIA.

Membros da equipe: Lucia Helena Valle, MSc

Prezado pai/responsavel

O diretor da escola de seu filho concordou em participar de uma pesquisa sobre como a aprendizagem das crianças é afetada pela tecnologia moderna, nesta era digital. Espera-se que cerca de 50 crianças da escola possam participar.

Cada criança envolvida completará uma atividade no computador, que iniciará por um video e depois responderá algumas perguntas sobre sua pesquisa na internet e sobre suas proprias respostas. O processo vai demorar não mais que 30 minutos por aluno, em uma sala diferente da aula normal. Isso acontecerá durante o horario normal de aulas e será supervisionado por mim, Srta. Lucia Valle. Eu estou trabalhando como pesquisadora aprovada em associação com a Universidade.

A sua criança não será identificada pelo nome que a análise da Universidade vai realizar como resultado da pesquisa. Pode ser que seja necessária a gravação em áudio das entrevistas com as crianças.

Eu espero que você se sinta confortável em concordar que sua criança participe da atividade e agradecemos antecipadamente a sua cooperação.

Você também pode retirar o seu consentimento para a participação em qualquer momento durante o projeto, sem quaisquer repercussões a você, entrando em contato com o Assistente de Pesquisa do Projeto, a Srta Valle, Tel: +4407739649599, e-mail: L.H.Valle@pgr.reading.ac.uk, ou simplesmente entrando em contato com a Direçao da escola.

Atenciosamente,

Miss Lucia Valle.

Appendix Five: Consent Form from parents

Research Project: ESTUDO DA INVESTIGACAO DA APRENDIZAGEM ONLINE

Nome da criança: _____

Nome da escola: _____

☐ Eu li a ficha de informações sobre o projeto e recebi uma cópia do mesmo.

☐ Eu entendo o que o objetivo do projeto é o que é exigido do meu filho e de mim. Todas as minhas perguntas foram respondidas.

☐ Concordo que meu filho assista ao video e complete a atividade online proposta pela pesquisadora

☐ Concordo que meu filho seja entrevistado pela pesquisadora e que a entrevista seja gravada em audio.

Por favor, marque uma das opcoes abaixo:

☐ **CONCORDO** que o meu filho pode participar neste estudo

☐ Eu **NÃO** quero que o meu filho participe neste estudo

Assinado _____ (Pais / Responsaveis)