Problem solving and critical thinking in a technological world

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The present chapter starts from two basic concepts: the idea that the process of human thinking happens through associative chains and that Problem Solving Instructional Strategies proposed by Polya are essential for teaching methods that intend to develop teaching based on independence and on critical reasoning. Therefore, the chapter develops in four parts: the first part makes considerations about the theme, focusing on the contribution of Gestalt Theory and the Constructivism concerning construction of critical thinking linked to the Problem-solving strategies. The second part evaluates how much technology really corresponds to reflexive thinking, considering that the weaves of the digital hypertext have nonlinearity. The third part presents the results of a piece of research that has studied different styles of practicing reading-browsing performed by young university students when developing their academic thematic search and of their interest, on websites. Finally, the conclusions present a critical discussion concerning this empirical material that shows itself very similar to the mental associative chains and the concept maps, confronting it with theories adopted.

Keywords problem-solving; reading-browsing; youth and internet

Human thinking, due to its complexity, has been target for much questioning in many fields of knowledge. Nowadays, when it has become fact that browsing on the internet prevails in our daily lives, the most optimistic people consider this activity as one that produces and enhances a new way of reading and that it increases the capacity to think. On the other hand, there is also a great fear that affects many teachers and parents in that the youth, the major users of the internet in its multiple possibilities, might leave the traditional reading pattern based on printed books. Books remain considered essential in order to acquire the “true” culture. So, and in that way the internet becomes the great enemy in such process.

Therefore, we wonder: is digital browsing one form of “reading”? Is using the hypertext so different from the process of thinking that, by opening many browsing possibilities, it disrupts the concentration of the young people?

We shall take these considerations as a start point for this chapter.

1. The Chains of Thought linked to the strategy of Problem-solving

First of all, it is a fact that the thought does not read the world lineally, but it operates in associative chains. Therefore, the act of thinking presupposes an organization basis – in this case the psychic organization – a system of representations of internal impulses, of the objects and bonds perceived in the real world, in the experienced moments and in the actions of the person, all of which received as information by the psyche.

Actually, the psychic system works twice: it changes internal and external perceptions into images and mental operations, always integrating them to what had already been recorded and structured. At the same time, it also modifies its own structures of operation, due to the constant arrival of new information in its system. The thought is, therefore, a massive associative network in constant metamorphosis. With that, the thought “skips” from one representation to another; it draws paths that bifurcate; it weaves webs. It goes beyond the perceived, creating associative networks that are not necessarily found in the real world. Actually, the thought is only “kept on track” if it is under the control of selective perception which is linked to reality.

Thinking is, therefore, a dynamic process that, at all times, faces the need to choose between paths in its networks. Through such possibility, after having received, recorded and given meaning to the information, and, above all, after having stored it, it is possible for the thought to work with mental representations of the external reality, visual, motor, tactile, language and movement, organized into structures of operation which are able to put the mechanism of anticipation into action. This might be the most important characteristic of its operation. It is from such structured thought that come the possibility for us to become organized and disciplined in our studies, or dispersive and refractory in situations at school.

This way of conceiving the process of thinking and, consequently, the learning process also, was developed by a group of scholars, the followers of the Gestalt Theory, initiated in Germany in the beginning of the 20th century who...
opposed to what the Elementary Theory proposed, at the time, dominant on the field of teaching and, mainly, on the teaching methods. Opposing the ideas that conditioning and trial and error were the best way to learn, and that the knowledge of something is always better if we divide into parts, the Gestalt Theory defended that learning is connected to perceiving the relations existent in what we are learning and also the relations that we establish with what we have already built, in other words, our experience. Therefore, the Gestaltists consider that the basic structure in the act of learning is perception (not sensations as thought the apologists of conditioning) and that such act includes concrete goals, ideal goals and, above all, the organization of the parts. For them, without these, there is no learning.

In fact, the Gestaltists belong to a larger theory group: the Structuralists. Structuralism is a mode of thinking and a method of analysis practiced by the sciences of the 20th century, especially in the area of human studies. It defends that a structure is more than the sum of the parts, or in other words, that, when we face a target, we should consider not only the parts that make it up, but also the way in which these elements are arranged, structured. Many theories belong to such philosophical view (the Structuralism), for instance: the Gestalt Field Theory of Kurt Lewin; the Theory of Genetic Epistemology by Piaget and Vygotsky's Interactionism Theory.

One of the fundamental concepts of the Gestalt theory is the insight, in other words, the perception more or less sudden of relations that have not been presented before; “realizing an exit” for a dilemma situation that gives conditions to keep trying to comprehend the world around us. It is the famous “Oh! I got it!” “Eureka”, that we say when, facing a troubling situation, we “magically” glance upon the beginning of its solution. With their ideas, the Gestaltists contributed much in order to have a great change in the way of teaching, validating the importance of teaching methods based on “problem solving”.

Realizing the “solution for a situation even though we do not clearly see the steps to solve it”, or “the solution of a problem”, happen because we have the mental possibility to have insights. In fact, insights connect among themselves, operate in a consistent way and end up becoming a structure founded in our thinking, the basis to plan the next action and indispensable for an independent thought. However, we have to bear in mind that not every insight is right; there are wrong insights as well. Also we will not have one big and efficient insight when we face a problem to be solved; rather we will have partial insights until we get to the “real” solution. But it is from their articulation, their going forward and backward that the realization of errors in our associative chain of ideas promotes real mental trials and errors, configuring the reflexive thinking.

Another important point is that the insights always belong to the one who is learning and, therefore, the teacher cannot offer an insight to a student. He can, however, offer conditions in his classes for the student having many insights. In such case, the best way for a teacher to conduct his student's learning is found in putting the content in doubt, making him think on how to build his knowledge, leaving behind the idea of offering the content as being ready, even if it is well organized in what concerns method. The “problem solving” teaching method is, therefore, a teaching procedure in which the student becomes the true builder of his knowledge. But what is a problem?

Problem is a concept that goes beyond mathematics. It is a start point for any questioning that is found as unsolved. It is any and every situation that is not totally comprehensible or clear in its relation with its elements and that, therefore, deserves a question or many trials in the search for its solution which does not have a one-way direction.

Polya [1], a great mathematician from the 20th century, follower of the Problem solving technique says: " If you can’t solve a problem , then there is an easier problem you can solve: find it. ... By solving many problems .you will find choosing a strategy increasingly easy . .... If you cannot solve the proposed problem , try to solve first some related problem ... Perhaps the first point, which is widely accepted, is that teaching must be active, or rather active learning". Well, such orientations perfectly meet with the ideas proposed by the Gestaltists.

Polya also says:

A great discovery solves a great problem but there is a grain of discovery in the solution of any problem. Your problem may be modest; but if it challenges your curiosity and brings into play your inventive faculties, and if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery. Such experiences at a susceptible age may create a taste for mental work and leave their imprint on mind and character for a lifetime. [1,p.v]

Polya proposes four steps when using the Problem-solving technique [1,p.5-12]:

. The first one is Understanding the Problem: "You have to understand the problem", he says. In this step, the solver is encouraged to find the unknown, gather the data and separate the data into parts.
. The second one is Devising a Plan: "Find a connection between the data and the unknown. You should obtain eventually a plan of the solution." In other words, in this step, the solver is encouraged to make connections to previously solved problems.
. The third one is Carrying out the Plan. In this step, the solver is encouraged to check each step along the way and think of ways of proving its accuracy.
. Finally, the forth one is Looking Back: "Examine the solution obtained." In this step, the solver is encouraged to check the result, think of other methods to solve the same problem and decide if the strategy could be used for other problems.

Our experience as teachers in many school levels have shown us that the adoption of problem-solving as a teaching strategy brings many possibilities for the act of teaching and it contributes for an effective learning. Therefore, the great
questions that come before us are: Is the reading-browsing that happens when we search for information on the internet so pleasurable because it corresponds to our chains of thought? And, in a way, is it based upon knowledge by problem-solving? This is what we will decipher!

2. The wefts of the hypertext on the web

During the 70’s, the philosopher, sociologist and scholar of the hypermedia field Theodor Nelson, when defending that the thought were structured in a non-linear way, adopted this idea and created in the context of computing the hypertext concept. This system made possible a type of simulation of what goes on in the human mind when reading and writing, and this ended up becoming the architecture of what was later on consolidated and diffused with the creation of the World Wide Web in 1990, through an application of information sharing proposed by the programmer Berners-Lee, one of the responsible for the WWW. [2-5] Berners-Lee actually continued on with a series of ideas and technical projects that had been developed years before, and they aimed to create possibilities of association of different sources of information through interactive computing, using associative trails idealized by Vannevar Bush in the 40’s. Vannevar Bush [6] considered sound the idea that human thinking organized and used the information starting from association links or associative trails, as well as he gave value to his invention by the relation that it presented with mental operation:

The human mind does not work that way. It operates by association. With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain. It has other characteristics, of course; trails that are not frequently followed are prone to fade, items are not fully permanent, memory is transitory. Yet the speed of action, the intricacy of trails, the detail of mental pictures, is awe-inspiring beyond all else in nature. Man cannot hope fully to duplicate this mental process artificially, but he certainly ought to be able to learn from it. In minor ways he may even improve, for his record have relative permanency. The first idea, however, to be drawn from the analogy concerns selection. Selection by association, rather than by indexing, may yet be mechanized. One cannot hope thus to equal the speed and flexibility with which the mind follows an associative trail, but it should be possible to beat the mind decisively in regard to the permanence and clarity of the items resurrected from storage. (n/p electronic media)

Therefore, if we consider, agreeing with Vannevar Bush, that browsing on the digital hypertext universe corresponds to the modus faciendi of human thinking, we already have the first step to understanding why using the internet becomes so attractive, allowing this diversity in the ways of reading, through clicks. Beyond the logical-sequential process presents in the spoken and written language, in the context of cyberspace, the hypertextual and multimedia processing of information predominates, with different paths for the construction / production of knowledge that is, therefore, based on insights.

Following the same line, Engelbart in 1968 proposed the possibility of manipulating the archives represented on the computer screen by multiple windows, using the mouse for that (which was also created by him). This device that allows the person to access these data was another step forward in the direction of a learning that is built on the web and that could happen from various possibilities. The On Line System, which is based on hypertext, made it possible for texts, images and videos to be presented at the same time and interactively; in other words, with Engelbart's invention, the user can point, drag, or expand the information content on the screen, intervening directly on it. Actually, Engelbart had created a new space that came to be explored by any user: the space-information – or contemporary interface. [2-5,]. Once more, the idea that the thought happens in chains and it can create relations from any knot is confirmed.

Landow [7], one of the pioneers on reviewing texts in electronic devices, understands hypertext mainly as a composition of blocks of text, images or sounds united by electronic windows activated through links that connect them, making multiple tracks possible in a open, unfinished textuality represented by the network (making very clear the relation between hypertext and web/internet). According to the author, hypermedia, interconnected to hypertext, expands the concept of text beyond the written code, covering visual information, sound and animation as well. This way, reading-browsing always happens when building digital hypertextual chains make it possible for the reader/user to explore its various routes, shown as a maze, but linked by knots or bonds that, on their turn, contain other chains and other knots, becoming a browsing structure with different textual possibilities (fixed and animated images, written language, sounds, etc.) which allow contents to be read and seized.

And more. For Landow, digital hypertexts demand from the reader a more active participation; in other words, reading in which he can, as he goes through its links, “dig” and find many kinds of texts that he might want to “realize” (select to appear in his screen), so that he can write his own version starting from various materials found on the internet. He becomes, therefore, co-author of the speech, the author being the one who creates and inserts blocks of texts and links, and the reader being the one who gets to decide which ones he wishes to read as from his browsing through tracks offered by the web. There we find an excellent possibility for teaching methods to change learning into a construction in which the student creates the structure of his knowledge.

If the nonlinearity is the most representative characteristic of the nature of the digital hypertext and if such technology is correspondent to the reflexive thinking, there is not, therefore, support for the two questions that were presented in the first paragraph of this chapter: neither technology does not create new and better ways to learn in itself,

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neither it is responsible for the disinterest in reading books pointed by many teachers. We dare say that, perhaps, it is producing much more reading for the youth, but in a different way, and showing more significantly that it is possible to learn better if we let the learner follow his course in a more independent way, creating his own ways to get to knowledge. But, in both cases, he will always need to have by his side the significant figure with whom he relates and who serves as signification role model, whether it is his teacher, parents or friends who are reliable to him.

3. What the young people say

In our long experience as researchers, we have run studies in the field of the relation between the young person and the Digital Medias at The Pontifical Catholic University of Rio de Janeiro (PUC-Rio) inside the Research Directory called Networking Young People (JER). Therefore, we have observed that the youth heard in the pieces of research, university or high school students, consider digital browsing as very significant, they point and give value to some features related to the revolution that was generated by the digital hypertext format, with its informational content, shown as an open work that articulates text, images and sounds. Language based on hypertextual architecture, when mixing different Medias, which were previously separated, is seen by them, young reader-browsers, as new ways of processing information and building knowledge that tend to vary between instantaneous and in depth, according to the way it is handled.

In a special way, the research developed as doctorate thesis by Fernandez at PUC-Rio is essential in the context of this chapter. It had as aim to register, analyze and comprehend the tracks, the ways and the reading-browsing strategies adopted by an intentional sampling of 10 university students from different courses and graduation semesters of PUC-Rio, when they searched the Internet for information starting from an academic requirement of their interest. All of them were users of the internet, and nine of them were frequently users of websites as source of research and pursuit of information. To follow each young person's reading-browsing in their search, she used the programme SNAGIT\textsuperscript{1}, which aims to capture, manage, handle and print images, texts and videos, with different configuration options for capturing the screen, and we also performed field observation and interview with the youth involved. During the gathering of the empiric data, it was possible to identify some recurrent actions by the youth, in the sense of appropriating the informational content presented to them on the websites that were searched. This allowed us to consider some search styles on the internet, of which we bring two: the \textit{back and forth} reading-browsing style and the style \textit{from tab-to-tab}.

3.1 \textit{Back and Forth} Reading-Browsing

Adopting this reading-browsing style, the youth perform their search based on \textit{comings and goings} [according to flowchart below], having as the only conducting line (or only search basis) the Google website, forwarding, returning and redirecting their search starting from tracks and from the list of website pages indicated by it. Let us see below the representation of such search map adopted by a young person at Fernandez's research:

\textsuperscript{1}SNAGIT is an application that is limited to the basic offered by many programmes. Besides that, the programme performs the task of capturing screens. In the websites case, it copies the whole page. Another action performed by it is video recording. This function can be useful for producing a visual tutorial and, due to its features, this programme was chosen in this research.
If we compare how this young person works with the phases proposed by Polya inside the Problem solving technique, we find the following:

The reading-browsing in a scanning form that the young person performs in his first take in searching finds great sympathy with the phase Understanding the Problem, in which the solver is encouraged to find the unknown. In order to clarify the first take, in other words, after his first reading, he does a selection and, on Microsoft Word, he copies and pastes the information that caught his attention, performing then the second reading of the content, which in some cases it might mean that he will print off on paper what he had summarized on Word.

The comings and goings until he sets his anchor-ground, which in the case presented above is the Google website, which redirects his search, when the web gets confusing, when the possibility to move forward ends or even when he wants to refine his search, correspond to Polya’s phase Devising a Plan, because it creates connections between the data and the unknown. On the other hand, during his whole search, the young person also gets support from a document on Word, filtering what he is interested in and complementing it with other ideas, because he is certain that his network of connections are kept and they will not get lost. Now, such procedure is implied on Polya's proposition, in its third step: Carrying out the Plan, because in it, the solver is encouraged to check each step along the way and think of ways of proving its accuracy.

When the young person tries, all the time, to keep control over each stage of the appropriation of pieces of information, aiming to build the connections and to fill in the gaps left by the pieces of text that he “digged” from the hypertextual space, he is in a way guaranteeing what was proposed by Polya on Looking Back. In other words, he can examine the quality of the material gathered and he can fix possible errors. It is interesting to notice that, as to make sure that he is effectively appropriating reliable information, he also tries to find two or three texts in different websites and compare them, performing, thus, a multilineal, pluritextual and plurisignificant journey, surfing on the web through comings and goings, and performing the entanglement and appropriation of pieces of information.

### 3.2 From Tab to Tab Reading-Browsing

Our experiences with studies about building knowledge makes us think that this reading-browsing method From Tab to Tab is mostly used by readers-browser that are not neophytes and that bear in a mind a plan of action. In this method of browsing the web, the reader-browser goes from tab to tab moved by one goal or many goals, related among themselves or not, aiming to perform a search task for more profound information, getting support from many sources since the beginning, either because he searches for different information about only one theme, specific or not, or because he wants to compare information about a generating theme, aiming to clear his doubts.
Let us see an example of this reading-browsing method, taken from the empiric data of Fernandez's research:

![Fig. 2 Browsing method, tab to tab reading-browsing, taken from the empiric data.](image)

In this browsing method, the search starts when different websites are open on tabs, even if one of them functions as a bridge to the others. The action to expand access to websites through tabs is basic, because according to a young person that joined the research “if there is a topic in the text that catches my attention and that is more specific for what I want, I look for it, or in other words, I open a tab to see it”. In some cases, it is also common to open the e-mail inbox or a game, which remains open during the search. This shows us that these reader-browsers are ready to perform multiple tasks, which is a very common practice nowadays, especially among internet users. According to the data collected by pieces of research developed by JER, we have formulated the hypothesis that the creative capacity of these reader-browsers originates various methods of action which make possible for them not only to deal with the plurality of texts found on the hypertextual networks where they trafﬁcate, but also to perform other tasks, as simultaneous as possible. In other words, the thought can operate, concomitantly, in different areas without, necessarily, getting confused, and browsing through the infoways helps the expansion of this mental web.

Johnson [5], citing the fact that part of Bush’s ideas for Memex are similar to the current experience with the Web, says:

> Recent advances in neuroscience suggest that Bush’s connective model might be a mechanic analogy to how the brain works: a group of neurons connected by tracks of electric power, generating information more from connections than from fixed identity. The brain does not keep one specific piece of territory for the idea of “dog” and another for a “cat”. The ideas emerge from the activation of thousands of different neurons, in combinations that get reorganized to each subtle meaning alteration. The connections among these neurons create the thought; the individual neurons are mere bricks, giving a previsibly strong emphasis to beneﬁts that the new technology promised the research, and less attention to, let us say, more recreative purposes (p. 89).

In reading-browsing “from tab-to-tab”, the reader rolls the screen down quickly, tracing down and scanning of the theme, always focused on websites that deserve more attention. In the same way, he uses Microsoft Word to take note of key-words and expressions, making sure that his search is reﬁned and aiming to achieve his goal more effectively. Therefore, they are like tabs, nodal points to add better observations, always conducting his attention focus.

In analyzing how the browsing model “from tab-to-tab” works, in terms of what was proposed by Polya, we see that the phase Understanding the Problem is quickly overtaken, once this reader-browser has the previous experience which makes it easier for him to be aware of the problem. Devising a Plan, Polya’s second step, is already structured in this reader-browser who does not admit clicking or typing aimlessly, arriving quickly to the third step, Carrying out the Plan, when he then performs his search based upon deﬁned objectives which conduct him to his investigation focus.
Polya's fourth step, Looking Back, is processed, therefore, by using the same logic used by the comings and goings reading-browsing style, because it works as to evaluate the quality of the websites combined and to make sure that the best gathering of information has been done. Now, this is only achieved by critical examination of all the material extracted in his search.

4. Conclusions

The experiences reported here leave us with no doubt of how profitable it is to adopt the teaching method that is based on the gestalt field theory and that adopts the procedures of conduction of teaching through the technique of problem solving, supporting itself on the thought that does not happen lineally, but in chains.

Having said that, we move forward to another crucial point in teaching. The on-growing diffusion of the internet in all areas of human activity and experience is a fact. It is here to stay, as did the printed book, the radio and the television.

If we observe attentively this platform of alternative life that is the internet, we realize that, inside the possible fusions between cultures, concepts, mediatic activities that are getting configured, at times more, at times less clearly in this environment, the phenomenon of reading-browsing has perceptibly been there in the ways of appropriation of the digital textuality of the users that go through its hypertextual architecture. Depending on the generating context of the construction of knowledge (immersed in concrete cultural practices) and on the features of the object that is to be regarded, understood, the individual uses different strategies (including reading strategies) that are alternated and adapted according to his experiences, previous knowledge, needs and interests. A complex and enlarged focus seems to arise from this dynamic process, reinforcing the value of the personal construction of knowledge and building of critical reasoning. And the ICTs have been contributing to that.

However, in what concerns school learning, there still is a great resistance from the teachers concerning the teaching that goes through critical reasoning of the content and that adopts other mediatic supports (as the ICTs). They are, without a doubt, alterations in the teaching practice that make the students independent in the school, but on the other hand, they might take away the vertical power of the teacher that has lasted for years.

There is, therefore, an urgent need to “reinvent the school”, performing changes in the mentality concerning the dyad teacher-student, since both have to break paradigms: the student by getting out of the comfortable position where he receives the content even if it is not interesting for him and, on the other hand, the teacher by taking a more horizontal teaching attitude that certainly would not remove him from his biggest job – the orchestration of his students’ learning.

We are convinced that it is only from the moment when such intent comes true, that we will be able to consider the real possibility that the consumers/users belonging to different human groups might become effective creators and agents of new socio-cultural uses and practices in the area of digital networks and educational contexts.

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