PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE

ESCUELA DE INGENIERIA

A COLLABORATIVE SEARCH MODEL FOR COMPUTER-SUPPORTED CLASSROOM ACTIVITIES

LEONARDO I. BARROS PEREIRA

Thesis submitted to the Office of Research and Graduate Studies in partial fulfillment of the requirements for the Degree of Master of Science in Engineering

Advisor:

MIGUEL NUSSBAUM VOEHL

Santiago de Chile, September, 2011

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A mi familia, amigos y a todos quienes
han hecho posible este proyecto.

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RESUMEN

Hoy en día, la búsqueda grupal de información a través de la web es una de las actividades más frecuentemente realizadas por los usuarios de internet, sin embargo, no existen herramientas que soporten dicho tipo de búsquedas. Tanto *browsers* como motores de búsqueda están pensados para usuarios solitarios. Por otro lado, las actividades colaborativas en ambientes pedagógicos, apoyadas por tecnologías de información, están tomando cada vez mas fuerza dentro de la formación escolar debido a su probado impacto en la educación y entrega de valores sociales y comunicacionales, primordiales en la formación del siglo XXI.

Identificando esta necesidad y tomando la fuerza de las tecnologías de información y comunicación, este trabajo propone un modelo de búsqueda colaborativa para actividades soportadas por computador en la sala de clases. El modelo consiste en un macro-script que define reglas necesarias para dicho tipo de actividades de búsqueda en grupo.

Los resultados del uso del modelo presentan preponderancias de hábitos cooperativos por sobre colaborativos, dejando en evidencia que el modelo por sí solo no es suficiente para asegurar colaboración, siendo necesaria la construcción de herramientas computacionales y micro-scripts que sean capaces de implementar el modelo y guiar a los alumnos en su búsqueda colaborativa.

Keywords: aprendizaje colaborativo, búsqueda colaborativa, búsqueda de información

Research supported by the Center for Research on Educational Policy and Practice, Grant CIE01-CONICYT, Games for Learning Institute, and Microsoft Research.

ABSTRACT

Today, searching for information in groups via the web is one of the most frequent activities that people do in the internet, however, there are no tools that support it. Both browsers and search engines are designed for single users. On the other hand, collaborative activities in educational environments, supported by information technologies, are taking increasingly more strength within school education because of its proven impact on education and delivery of social and communicational skills, fundamental to the students 21st century formation.

Identifying this need and taking the power of information and communication technologies, this paper proposes a model of collaborative search for computer-supported classroom activities. The model consists of a macro-script which defines necessary rules for this type of search in group activities

The results of the work made with the model shows preponderance of cooperative habits over collaborative ones, leaving in evidence that the model by itself is not sufficient to ensure collaboration. It is required the construction of computational tools and micro-scripts capable of implementing the model and guiding students in their collaborative search activities.

Keywords: collaborative learning, collaborative search, information searching

Research supported by the Center for Research on Educational Policy and Practice, Grant CIE01-CONICYT, Games for Learning Institute, and Microsoft Research.

I. INTRODUCTION

1.1 Motivation

Searching for information in groups has become one of the most common practices in the educational area. Investigations like those of A. Large (Large et al., 2002) highlight that the great majority of the school homework, including projects or investigations, is carried out in groups, avoiding the solitary work. In the same way, there have been carried out interviews to librarians and teachers (Amershi & Morris, 2008) who point out that students, either primary or secondary , prefer to work collaboratively. The collaborative work develops social and communicative abilities, being a desirable attribute in the school formation of the XXI century (Zurita & Nussbaum, 2004-A). For this reason, teachers encourage classroom activities in groups as part of the teaching.

The use of technologies of information and communication (ICT) in the classroom activities has become more and more common, being included in the educational politics in an implicit way (Moonen, 2008). Each year there are more schools in all the cities of the world that are connected to the Internet. This tendency, that will probably be maintained in the future, results in that many children and young students consider the Web as one of the most important sources of information to support the classwork (Large et al., 2002).

This paper unites education and technology with the objective of developing a model which will give bases for creating investigation activities to carry out in groups.

1.2 Collaborative Search

Before building a pedagogic model which implements the collaborative search for the development of an activity of investigation in groups, it is necessary to understand: What is the collaborative search? What are their characteristics? Which are the differences and advantages with other search types?

1.2.1 Cooperation in the search task

Studies show that most people want to collaborate with friends, family and colleagues when they search in the Web (Morris, 2007). It is also observed that the groups of

collaborative Internet search are usually formed by two or three people (Álvarez et al., 2010; Amershi & Morris, 2008).

Among the ways of collaborative interaction, four common types are identified (Twidale et al., 1997), these forms are the followings:

- Joint Search: a small group of collaborators work around a single computer, planning their next steps together.
- Coordinated Search: a group of two or more people work in different computers, one beside the other, sharing what each one does and the results of his/her searchs. In some cases, certain competition is generated among the collaborators.
- Free Query: each member of the search team works in his/her own computer next to others teammates, being occasionally able to interact (making questions or comments), asking for help or monitoring the work of his/her partner.
- Chance Contact: Similar situation to the above, in which the interaction moments are generated when two or more people are in the same place, allowing face to face communication.

Although the search in groups through the web is a surprisingly common activity, there are not technological tools that support this practice in an appropriate way (Morris, 2008). In educational environments, (Twidale et al., 1997) observed that the most common collaborative methods used by the students when looking for information are the Joint Search and the Coordinated Search, highlighting the fact that none of these two work ways is supported by the search systems in libraries.

The traditional model for the information search, who gives a conceptual framework of the behavior of the search user, does not contain representation of any other partners more than the single user, omitting the interaction with other people (Twidale et al., 1997). This model is assumed by many search tools (Broder, 2002), in none of them is considered the participation of more than one person at same time (see Figure I.1).

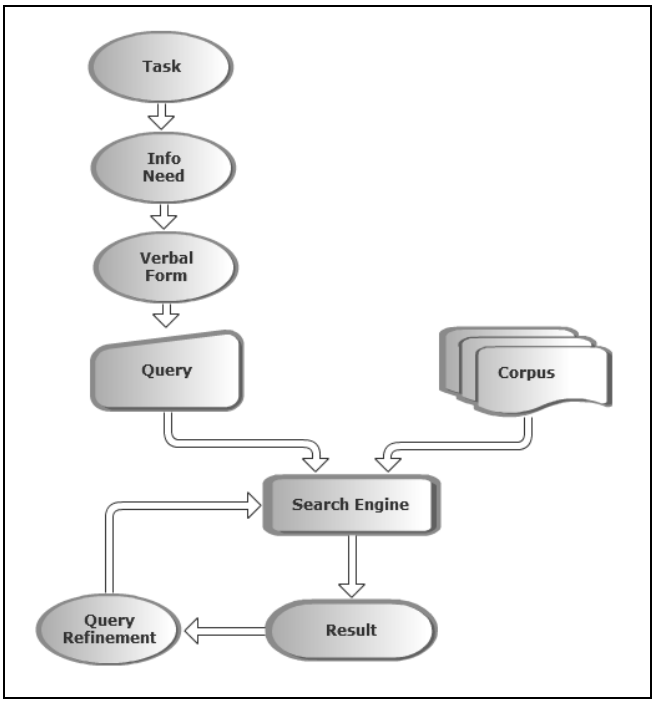

Figure I.1: Classic Model of Information Retrieval (IR) on the Web (Twidale et al., 1997)

However, in spite of the technological restrictions that impose the information systems when allowing only individual interaction, the cooperation among peers continues rising like a way of work (Large et al., 2002; Twidale et al., 1997). Considering the previous evidence it is valid to ask: is it possible to have tools that support the search in groups, accepting that is a very common practice?

1.2.2 Search in groups versus collaborative search

It is not the same thing to speak of cooperative work (or work in groups) that collaborative work. The collaborative learning (CL) environments have become an important aspect in what refers to education (Szewkis et al., Accepted for publication) even over cooperation activities. This due to the contributions observed in the education and in the student's personal formation produced by collaborative learning environments. The cooperation only contemplates the division of work within the group, where each member is responsible for his/her action. On the other hand, the collaboration is defined as the coordinated work of a group of individuals to solve a problem where all the members are responsible for the result (Szewkis et al., Accepted for publication).

The collaborative learning is considered a methodology that allows the members of a group articulate its points of view, to negotiate and to exchange knowledge and beliefs, and to jointly co-build new knowledge. This way, the learning is achieved through a process of knowledge construction (Infante et al., 2010; Zurita et al., 2005), reaching benefits like a better achievement in the learning objectives, the increase in positive interdependence and in the student's motivation, while he/she acquires social abilities and new ideas (Nussbaum et al., 2009).

To really achieve the maximum profit of a collaborative activity, six approaches must be completed. These criterias were established through diverse studies and gathered by (Szewkis et al., Accepted for publication). The approaches are: (1) to have a common goal, (2) create positive interdependence, (3) achieve intragroup communication and coordination besides (4) individual responsibility, (5) awareness of team work and, finally, (6) receive a joint reward.

Although the collaboration benefits are certainly identified, it is very complicated assure that in an educational activity the six criteria of collaboration will be fulfilled, because it is required a constant supervision to the process of knowledge construction and correct evaluation of the results, task that surpasses the capacities of any tutor.

Facing this fact, arise the need of supporting the collaborative work with new models and tools that guide the process to help the teachers' work, improving the coordination and communication, the mediation among peers, the conscience on group's work and the execution of specific rules of each activity. It stands out the importance of generating a collaborative process that allows an appropriate search in groups. As pointed out by (Morris, 2007) creating a work system that allows the collaboration in the search of information, not only will allow their users to formulate better queries and help to refine them, it will also improve the search experience, mainly by:

1. Better space covering of the pertinent search places, reaching results of high quality.

2. Users are more confident in the completeness and/or correctness of the search.

3. Better exposition to different search strategies and queries syntaxes, because each user will have his/her own researching ways.

4. Increase of productivity due to the decrease in the redundancy in the information search.

1.2.3 Characteristics and different forms of collaborative search

There are numerous investigations that establish the requirements for an appropriate collaborative search environment for educational purposes and the advantages that this would achieve.

In benefit of a better collaboration among members of a group, it has been observed that groups of small sizes (2 to 4 people) allow better participation of their members, obtaining consensual solutions in the development of investigation homeworks (Valdivia & Nussbaum, 2009).

(Morris et al., 2006), through their comparative investigation, determined that the collective formation of search queries has great advantages, mainly in the coordination and awareness among the members of a group, allowing to take benefit of the abilities, techniques and preferences in the Web search of each member. Considering the search like an iterative process, the cooperation in the query construction accelerates the refinement of these, which is directly related to better search results (Morris, 2008).

To take advantage of the experience, especially from the educational point of view, it is not only important to communicate the product of the search, but also the process of it (Szewski et al., Accepted for publication). However, to share the process of web search, it must be determined which modality of collaboration should be used: the Coordinated or Parallel Search, where each user has a personal interface in communication with the other ones; or the Joint Search, in which the interface would correspond to a shared vision, in which all the members of the group see the same thing.

Either ways of interaction, Joint or Coordinated, will allow reaching the approaches of collaboration. Each one, however, has certain advantages and disadvantages in the way collaboration is expressed. For example, (Morris, 2007) analyzed these options from the point of view of the division of work: The strategy of "divide and conquer" that is identified with the coordinated search, requires planning and specific coordination among couples, with a specific division of the search space, either through a division of search terms to use or a segmentation in sub-tasks that each member of the group can take. On the other hand, the strategy of "brutal force" does not involve explicit planning during the search process, which possibly produces duplication of effort among the group partners. In this sense, an explicit division of work can be more efficient in the development of the search.

Nevertheless the above-mentioned, other studies (Morris et al., 2006) have shown that a parallel outline of work (similar to the Coordinated Search) does not show better efficiency that an outline of shared work (or Joint Search). From the point of view of the time required to complete the work or in the embraced space of search, between them there are not significant differences observed in the outlines. However, it was determined that a collective interface offers more benefits, because it allows strengthening the collaboration and the awareness among the group members.

An outline of joint work has advantages from the point of view of the communication and the group conscience, besides of making more effective the formulation of queries; although it produces effort duplication and less complete results, diminishing the motivation and increasing the frustration of the students. Instead, a coordinated outline of work allows a better planning, achieving a more complete result and eliminating the redundancy; affecting the communication and the awareness of the work at group level, which affects in the commitment of the group towards the obtained result (Amershi & Morris, 2008).

The above-mentioned clarifies that none of the two strategies is positioned over the other one, for which is ideal combining both strategies in a way that allows joint and coordinated interaction. This makes clear (Morris, 2008), who highlights that the users are interested in an interface that allow them to parallelize tasks without duplicating effort, this implies a parallel outline with high coordination and awareness of the group

work. Focused in diminishing the duplication of unnecessary effort, it becomes a requirement to achieve a high level of conscience among peers on the search queries that it uses each one and to use shared views where you could appreciate the results of the other members team (Morris, 2008), but it should be maintained the possibility of parallel work and certain independence among the users, to use the search techniques that each one chose.

Based on the answer submitted by interviewed people, the study carried out by (Morris & Horvitz, 2007) allows settling down three requirements that should cover an effective interface of collaborative search: awareness of group work, effective division of work and mechanisms of persistence of the process and their results. When analyzing each one of these requirements in detail, you can appreciate with more clarity what is expected from a collaborative search system (Morris, 2007):

- Awareness. The information that is important to maintain visible for team partners are the key words used in the search, the visited pages and the annotations of these ones (e.g., comments, labels, valuation), recognition methods to identify responsibilities, besides maintaining direct communication channels.

- Division of work. Most of the interviewed people recognize to use methods of work division within the search in groups; methods that are adapted to the necessities and the context of the users. It is necessary, then, to incorporate mechanisms that allow a division and assignment of work in agreement to each situation. This has to be flexible according to the users requirements under the strategy ' divide and conquer'

- Persistence. It refers to save the search session so that it can be rescued or loaded in the future, which facilitates the collaboration among peers and with oneself through the time. The information that is more important to store is the topic, the product and the process of the search; that is to say, to store the utilized web sites and the used queries that allowed to achieve the search results, which allows to communicate what search techniques has been used and which was more effective (Morris, 2008). It also stands out the

importance that these data are saved in an implicit way, so that the user should not worry about constantly saving while he/she navigates through the Web.

In accordance with the study of (Morris & Horvitz, 2007)), the groups' awareness is the most important aspect in a collaboration interface, being the most valuable and used resource.

Recent studies have been focused in the requirements that a collaborative search system should have for supporting multi-user searches. These conditions should be completed to achieve a facilitating interface (e.g., Morris, 2007; Morris, 2008; Amershi & Morris, 2009). Mainly, (Twidale et to the., 1997)) points out that to achieve a correct collaboration during the search process, the users should be allowed to do the following things:

1. In any moment during the search process and construction of the result, anyone of the participants can consult or request help to their partners to improve their personal result.

2. Share recommended results of the search process, so that although the work can be divided, each individual can participate passively of the search of his partners, strengthening the coordination, commitment towards the activity and the efficiency of the search.

3. In the event of requiring it, the users can add value to the obtained results, attaching personalized information that facilitates the organization or complementing the gathered information.

Another very important aspect to consider in the collaborative learning environments is the professor's role like supervisor and guide of the process (Infante et al., 2010). In the collaborative search, the professor abandons his traditional role of expert that gives his knowledge to the students to become a constant observer of the process, allowing the students a bigger degree of autonomy since each student decides, in a free way, where navigate and how to value his results. However, it is important that the professor supervises the complete process and intervene in the correct moments so that the students do not lose the workflow.

1.3 Understanding Model

Another key point of the search is the way we understand it. When an investigator faces a search, there is a process in which the user should order the data of its search, be predisposed to it, execute it and finally, once concluded the search process -successful or not -, evaluate the quality of the search and the necessity to continue in it or decide that the process has to be concluded.

This process follows the Understanding Model (Wechsler et al., 2004) of a search. Every time that an activity of investigation and summary of data begins through a search engine, the user starts an understanding process of the activity. The way how people understand is a highly complex process that carries out the mind without being aware of the realization of it. In Figure I.2 it is pointed out the general understanding model; this model receives as an input the data of that we have, affected by our cultural and historical context. The process is cyclic and consists of a procedural dimension (left column) and cognitive actions corresponding to each stage (right column).

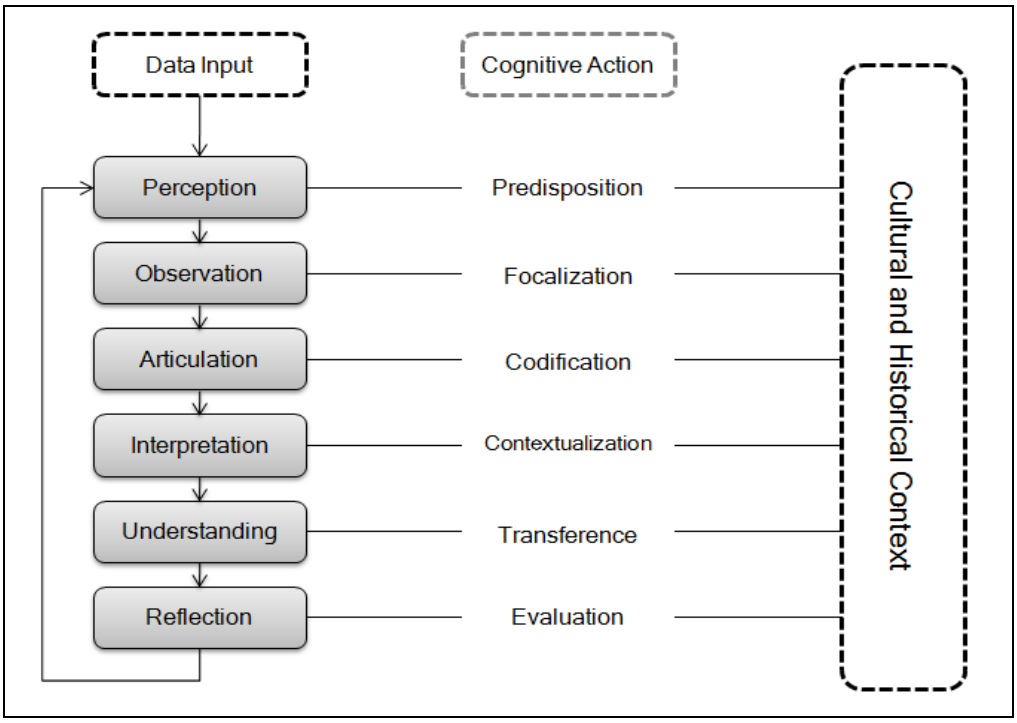

Figure I.2: Understanding Model

In the context of a web search, the understanding model can be applied, stage to stage, in the following way:

1. Perception. It is the initial stage of the search. In many cases it does not exist certainty of what is wanted to look for, how to search or what to expect from the results. It only exists perception of what is expected. That goes directly correlated with the bias toward the search and its results.

2. Observation. Starting from the obtained results, a focalization exists. It is not possible to process all the results of a web search, generally these are too many, varied and some of them escape the reach of the search. The focalization process only delimits the search results to those that the user wants to establish his/her attention.

3. Articulation. The articulation in search is the capacity to code -and to decode- the observed and focalized results. Coding is the process of transforming the search message into a personal message through a well-known language. For example, a search result that is in a language that is not known by the user will not be able to be decoded and therefore, he/she will not be able to understand it.

4. Interpretation. The articulated information is interpreted according to varied approaches like the context in which the search is carried out, the objective of the search, the history and culture of the user, among other variables. Interpretation refers to the specific contextualization of the coded information.

5. Understanding. Once the information is focused, coded and contextualized the search is finally understood. Understanding refers to the ability to assimilate the results of a search in order to make it part of our own knowledge, and then eventually make use of the information in a knowledge transfer to other media or individuals.

6. Reflection. The final stage of the understanding model relates to the evaluation of the results and the search achievement. It is the instance to assess the future

lines of action from the search, either through a new search, a refinement of the current one or the end of the process.

The linking of the principles of collaborative search with the framework of the understanding model will create a model to be followed for the creation of an activity to search in groups, implementing the collaborative search as a tool for achieving better results in research and learning.

1.4 Hypothesis

This investigation sets as its hypothesis that, faced with the current needs of Internet search and the positive results of collaborative learning, using a model of collaborative search –instead of a traditional cooperative search- will enable high school students acquire curriculum content knowledge and fostering a superior individual learning.

1.5 Objectives

The objective of this project is to create and propose a model of collaborative search that implements the features of collaboration on search to use it as a teaching tool. This model will be useful as a guide for the development of investigation activities in groups on a context of school work.

In particular, it is expected to measure the usability of the script; script that has been built based on the collaborative search model and applied on an investigation activity for school work. It will be taken into consideration the usability dimensions defined by Nielsen (Nielsen, 1993); these are “easy to learn”, “efficient to use”, “easy to remember”, “few errors” and “subjectively pleasant”. In addition, it will be verified if the model really helps the acquisition of knowledge through the application of a pre and post knowledge test with questions related to the investigation following the collaborative search model designed and proposed.

1.6 Methodology

To carry out the objectives of this project -and confirm or reject the initial hypothesis- the tasks outlined in this section have to be accomplished.

As a first instance it will be submitted a proposed collaborative search model design for pedagogical use. For the construction of this model the understanding model will be used as a base.

Once having the first version of a collaborative search model, an investigation activity is going to be designed to be carried out in groups and implemented at a high school. The experience will serve as an experiment for evaluating the parameters of usability and knowledge that are expected to be measured as a result of the implementation of the project. In addition, this activity will show the effectiveness of the model in a real group investigation activity.

During the implementation of the activity, a pre and post knowledge test is going to be applied (before and after the activity, respectively). The tests will be based on the topic of the investigation activity of the experience. Also, once concluded the activity, each participant will respond a usability questionnaire in an individual way indicating what was his/her perception on how usable the model was.

Once obtained experimental data, the next step will be the analysis of these results for assessment of shortcomings and possibilities for improvements on the model, expected future work and conclusions.

1.7 Collaborative Search Model for Educational Purposes

The first version of the collaborative search model was built based on the understanding model. This model takes the personal cycle of understanding and the search for information as a basis to extend it, in order to create a process of group understanding where it joins the way of understanding the search of two or more people. Broadly, this proposed model should consider the stages that define the rules for the search, their motivation and scope; search terms used; the search itself, both personal and in groups; construction and finally an answer to the question proposed for the investigation and integration of knowledge from researchers.

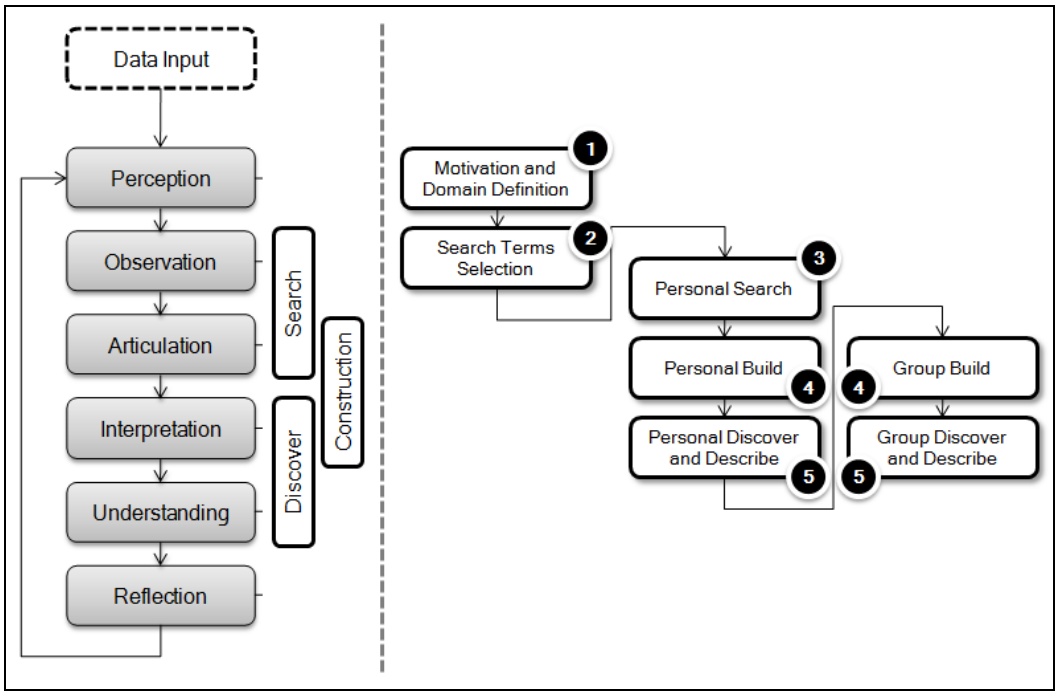

Figure I.3: Understanding Model and first collaborative search model

Figure I.3 shows a superposition of the understanding model in conjunction with the identification of five-stage bases that characterize what would be the collaborative search model. New stages correspond to (1) an initial motivation and domain definition, (2) selection of search terms, (3) web search, (4) construction and (5) discover and describe. The stages of motivation and search are absolutely personal, while construction and discover and describe cycles have a personal trial and then continue to a group stage. The new organization of the collaborative search model (see Figure I.4) represents a linear process that describes a first approximation to the collaborative web search.

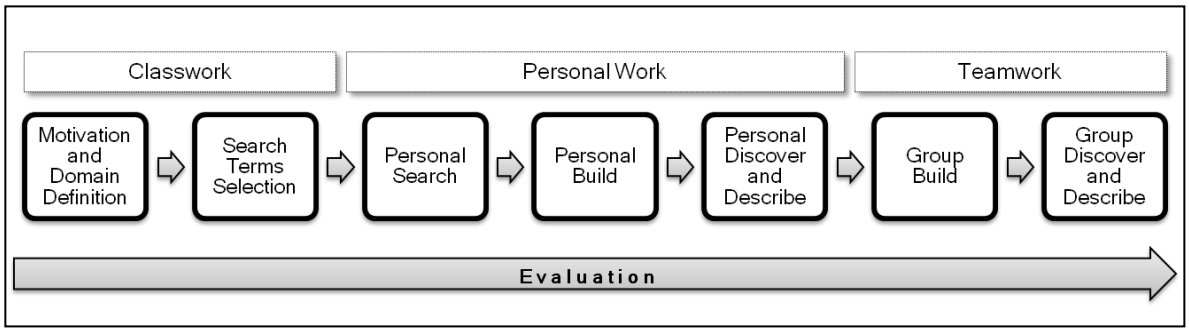

Figure I.4: First collaborative search model

From this model on, it is possible to define the general characteristics present at each stage of the collaborative search. Thus, each stage can be defined as follows:

- Motivation and domain definition. A guide user -for example a teacher - motivates the start of a search to the students. The guide defines topic, purpose, scope and rules to follow in the search.

- Search terms selection. Students relate key terms with the central theme of research in a brainstorm. These keywords will be the input of their search.

- Personal search. The student searches for information, through a virtual repository, using a query made by him/her. Through a reading view the user can see the results of his/her search being able to select, filter, value and save the results of the search. Despite the fact that this is a personal stage, it is necessary initiate communication with the rest of the search team in order to share querys, information and results.

- Personal build. The student is capable of making small summaries of the sites in which he/she has focused the research. She/he is able to classify these syntheses according to his/her information.

- Personal Discover and Describe. The student is able to organize his/her personal synthesis in order to be able to transfer or explain them to others following a logical sense.

- Group build. From the individual synthesis of each team member, the group should organize the information again, to create a logical map that serves as a first approximation to the answer of the original question of the investigation. If this map is incomplete or inconsistent, the team should do new searches to complete it and fix it.

- Group Discover and Describe. From the group synthesis, the participants of the research should be able to build a final joint answer to the question of the investigation on any medium: written, audio, video or other.

1.8 Experimental Design

To validate the model of collaborative search a research activity involving nine students of high school was carried out. The nine students were divided into groups of three.

The research work was on the "Latin American bicentennial". The students followed the model of collaborative search proposed in this project. The students answered a pre and post knowledge test. The pre-test was conducted before the start of the research activity, prior to any made introduction to the research topic; on the other hand, post-test was conducted upon completion of collaborative search activity. Both the pre and post testing of knowledge were answered individually by each of the participants of the experience. Both test consisted on the following knowledge questions:

- What takes place in Latin America in 2010?
- What was held in Latin America in 1810?
- How could the Independence of the United States relate to the Latin American?
- How influenced the French Revolution on Latin America?
- Name prominent characters for the Western world of 1810
- How could you relate Spain and America during the 18th and 19th centuries?

These questions were evaluated with 1, 2 or 3 points whether they were incorrect, incomplete or correct.

In the case of measurement of usability, a questionnaire had to be answered on an individual basis using a five-level likert scale. This survey was fulfilled once the research activity ended. The survey included questions for the evaluation of the participants' perception in the factors of "easy to learn", "efficient to use", "easy to remember", "few errors" and "subjectively pleasant". In each question the participants of the experience should respond if they were strongly agree or disagree with a certain claim. Table I.1 presents the detail of the questions asked for the measurement of each of the five usability criteria.

Table I.1: Survey questions about the usability in the collaborative search model

Criteria	Objective	Affirmation
Easy to Learn	Evaluate how easy it is to appropriate the model presented in the script.	- It makes sense the way in which information was sought.
Efficient to Use	Evaluate the knowledge reflected in the output of a group investigation using digital tools.	- I learned new things within the activity - The work was simple. - The work was made quickly. - The division of work was equitable.

Easy to Remember	Evaluate the student's capacity to model, identify and recall the steps followed during the investigation.	- I recall what where the steps of the process. - I could repeat the process without the need of a guide. - I am able to identify the parts of the search process.
Few Errors	Identify the sources of overhead and loss of productivity that emerged during the investigation.	- It is difficult to make mistakes by following the instructions. - Working in group allows me to perform better. - Working time was enough.
Subjectively Pleasant	Evaluate the user's assessment of the overall experience and the motivation towards the task.	- The use of sticky notes for ideas synthesis was agreeable. - It was nice to work in groups. - I would repeat the experience.

The data obtained after the application of questionnaires in the pre and post knowledge test as well as the results of the usability survey will be presented in the following section for measuring the perception of the usability of the collaborative search model according to the participants of the experience.

1.9 Results

The follow-up of the implementation process of the collaborative search model in a school research activity was in general positive, fulfilling an activity following the suggested search script. The students were able to understand, follow and implement each step of the process, supported by a guide.

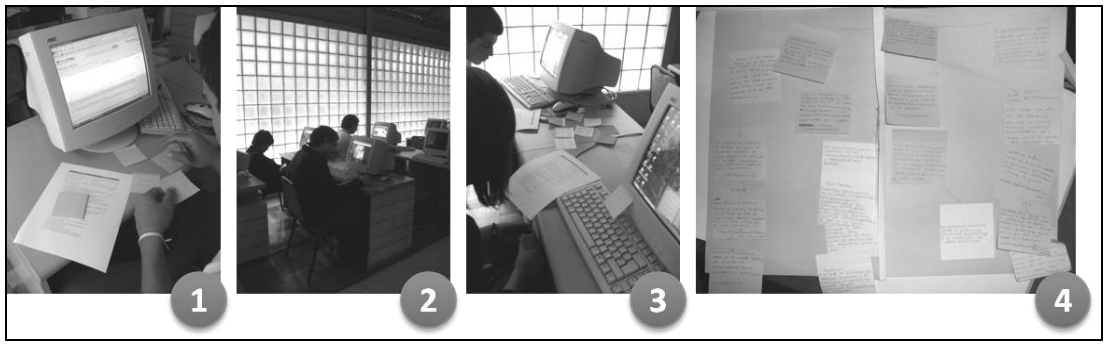

Figure I.5: An activity of collaborative search.

As shown in Figure I.5, the students were able to (1) do a personal search and (2) organize groups of search. Once the search was completed, each team (3) gathered their pieces of knowledge to, finally, (4) give a logical sense and of common agreement for all through a final construction.

The results of the test applied to the students who participated in the experience are shown in Table I.2. Each response was assessed as incorrect, incomplete or correct; assigning 1, 2 or 3 points respectively, depending on the case. Thus the average maximum for each evaluation was 3 points, while the lowest was only 1.

Table I.2: Results of knowledge validation in collaborative search model.

	Pre Test	Post Test
Average score obtained	1,89	2,39
Score standard deviation	0,82	0,76

Note that the difference between the results of the implementation of the pre and post test has a p-value of 0.0014 and a significance level (Cohen's d) of 0.64 points, i.e., medium effect significance.

In the case of the measurement of the perception of the five Nielsen's usability criteria, respondents answered according to the data shown in Table I.3. The 5 levels likert scale (from "strongly agree" to "strongly disagree") was rated with 5 points when responses identified completely with the filed claim and only 1 point to those claims in which the

respondent does not felt identified at all. In this way those attributes that are rated close to 5 are perceived within the model by the student, while those who have a value closer to 1 were not perceived or recognized by the participants of the experience.

Table I.3: Usability results on collaborative search model validation

Criteria	Average evaluation criteria	Evaluation criteria standard deviation
Easy to Learn	4,4	0,73
Efficient to Use	3,9	1,21
Easy to Remember	3,9	1,02
Few Errors	3,6	1,12
Subjectively pleasant	4,6	0,45

1.10 Results analysis

According to the obtained results in the pre and post knowledge test, it is evident that the activity manages to improve the initial results, doubling the number of correct answers and rising up the average score of participants in a 26%. In addition, not only improved the outcome and quality of responses, it also reduced the variability of responses. This is evidenced by a 7% decline in the standard deviation of the average scores between the two samples.

In the case of usability, two criteria positively outstand above the others. "Easy to learn" and "subjectively pleasant" are perceived more clearly in the model, which indicates that it was easy for participants to understand the searching process, give a sense to the way things were done and that they agreed that this was overall a pleasant experience. However, it highlights the case of “efficient to use” and “easy to remember”, two criteria which were poorly evaluated. In the case of the efficiency it became clear that having a model and follow a script on its own is not enough, it is also necessary to have a technological tool that supports the monitoring of the script, because perform the process manually is tedious: there is no way to make tracking of keywords, searches and results of the group; it is required to manually transcribe information from the web for the

synthesis of information; it is necessary to re-transcribe information from the personal essay to the group document, etc. In the case of the item “few errors”, arises the linearity problem of the process and the fact that the way that follows the script does not iterate in search stages. In addition, for this same criteria, each one of the stage's restrictions should be relaxed so that there will not be overscript of the activity, it is necessary to leave open spaces for the flexibility in the application of the model.

Even considering the cases of “few errors” and “efficient to use” criteria, the participants of the experience evaluated the model as usable, scoring all the criteria above three points, that according to the likert scale used is the point that makes the difference between positive and negative.

1.11 Future Work

It is possible to say that the model of collaborative search is a good first approximation to a script for group research activities. The model is considered to be usable and shows good results in the acquisition of knowledge related to the research carried out. However, the model has shortcomings such as lack of efficiency and “few errors”.

The development of tools that can support the model in a computational level is essential for efficiency. In the case of efficiency, the linear design of the collaborative search model has been showed to Pierre Dillenbourg, Professor at the EPFL; Switzerland, Computer Science Ph.D. at Lancaster University and an expert in education and collaboration, who despite being in accordance with the general structure, criticized the extreme linearity of the process. He suggested giving greater freedom to the students for seek and build. Although there could be cases in which the search and investigation are lineal -for example, when the subject of research is very simple or known to the user- these cases are a particular situation. It is necessary to refine again the process of collaborative search to create a non-linear version of the process which considers iterations on its way to improve search and construction processes.

Finally, the understanding model gives a procedural and cognitive framework to the collaborative search process; however, there is also a part of the way how we seek for the information. The process of searching for information is the construction in which the user, who actively pursues knowledge, is immersed in a search to make sense of

information found in a period of time. This process of how we search has been previously studied (Kuhlthau, 2010) and is known as the Information Search Process. Procedural, cognitive and emotional dimensions of the ISP will be included on the model of collaborative work proposed in this research.

Parallel to the realization of this project, a computational tool that supports the structure of collaborative search proposed has been built. It will be important to identify how collaborative search model behaves when is taken to a computational implementation to guide students through the stages of the process. Based on this information new refinements to the model of collaborative search can be made and also validate existing elements of the tool.

1.12 Conclusions

The proposed model meets usability objectives, i.e., as a first approach to a model of collaborative search to use on school research activities is well received by the students. In addition, when using the model in a real activity, it is noticed the positive impact on the performance when answering knowledge questions about the investigation correctly. However, the model is still far from perfection and needs to be redesigned at certain structures in order to make it more flexible, iterative, and not fall into the problems of overscripting.

What is presented in this paper is a structure or guidelines to be followed for the development of a research activity on the basis of collaborative search. This macro structure must be necessarily accompanied by a specific definition of the activities to execute during a process of investigation or collaborative search. The specific implementation of investigation activities is being carried out through the construction of a computational tool that implements the collaborative search model proposed in this investigation, the analysis of results and impact that this tool has on the proposed model is future work.

II. A COLLABORATIVE SEARCH MODEL FOR COMPUTER–SUPPORTED CLASSROOM ACTIVITIES

Searching online is one of the most powerful resources today's students have for accessing information. Searching in groups is a daily practice across multiple contexts; however, the tools we use for searching online do not enable collaborative practices and traditional search models consider a single user navigating online in solitary. We have developed a three level conceptual model that enables the implementation of collaborative search classroom activities. This paper describes each stage of said model and presents the theorical bases for conceptualizing multi-user collaborative search scripts. Empirical evaluation of the model shows improvements in the students' learning outcome and better collaborative dynamics within the group when compared to non-scripted group search. Future works is expected to develop specialized software that allows automatic following of the model presented and unify the software tools required for each stage of the process (search engine, word processing, instant communication, etc.).

2.1 Introduction

2.1.1 Collaboration in the search task

Searching for information is one of the most common tasks we carry out on the Internet. The traditional model for information searches considers a single user, omitting interaction with other people (Twidale et al., 1997). Because of this, the tools we use to search for information on the Internet –search engines, as well as network access interfaces- are mostly designed for the user to search individually (Broder, 2002). Collaboration in the search process can happen in various contexts, such as education, work, or social interaction (Amershi & Morris, 2009); however search engines cannot handle this characteristic, forcing users to turn to complimentary methods and tools. An example of this is the use of a single computer, with one user leading the search, and another looking over his shoulder, sharing search results via email, or coordinating joint searches through instant messaging systems (Morris, 2007). This translates into processes that produce redundant and incomplete search results, that don't reach all parties interested in obtaining the information (Amershi, & Morris, 2009). There is a distance

between the functionality offered by the technologies we use, and the practices of users searching for information on the Web.

Regardless of the activity that is being carried out, it is important to distinguish between cooperation and collaboration in joint Internet searching. The difference between what is considered collaboration, and what is called cooperation is often unclear. Cooperation refers primarily to the division of tasks within a group, where each member is responsible for his own actions, while collaboration is defined as the coordinated work of a group of individuals to solve a common problem together, where all members are responsible for the end result (Roschelle & Teasley, 1995; Dillenbourg, 1999). We could say that cooperation is similar to what factory workers do in an automobile assembly line, where each worker is responsible for carrying out a specific action, and is only worried about completing said action successfully. Collaboration, on the other hand, can be compared to putting together a puzzle, where everyone helps on any part of the puzzle and is responsible for a misplaced piece. Cooperative searching is actually a union of individual searches, and doesn't offer a technological challenge to the tools we use today. However, when users are faced with the need to work together to solve a problem regarding lack of information –for example, the task of performing a joint investigation- collaborative searching faces us with the need to restructure our tools to include the possibility for users to search and build solutions and answers to questions, together.

Collaborative behavior in the search process and the lack of tools to support it has been extensively studied in recent years. (Amershi & Morris, 2008) identified a series of limitations that present themselves when users that share the same physical space (presential) search for information together on the Web without tools that have been specially designed to promote collaboration. These limitations are:

(1) Difficulty to contribute. There can be complications in the search if the surfing users –those who control the mouse or some other similar device- are not able to work together with the observers.

(2) Lack of awareness. It is possible for participating users to be unaware of how their workmates have been searching, or what they have found.

(3) Lack of practical learning. Users who are not in control are deprived of exploring the Web.

(4) Loss of information. Teams without a good backup system to save and track information can lose their search results, or the keywords or queries that lead to said results.

On the other hand, the success of collaborative dynamics in group work depends on six criteria that have been established in several studies, and were summed up in the work of E. Szewkis (Szewkis et al., unpublished). These collaboration criteria are:

- Common goal: a common objective, shared by all the members of the group (Dillenbourg, 1999).
- Positive interdependence: correlation between peers' work, so that the success of each member depends on the work of his teammates (Johnson & Johnson, 1999).
- Coordination and communication: strongly related to negotiation. With the right coordination, a high level of communication and cooperation can be reached (Raposo et al., 2001, Gutwin & Greenberg, 2004).
- Individual accountability: each member of the team is responsible before his teammates for the actions he carries out and their consequences (Johnson & Johnson, 1999).
- Awareness: each member of the group can obtain information about the state that the work is in regarding both the group work and his teammates' individual work (Zurita & Nussbaum, 2004-B).

- Joint rewards: depending on the results of their work, the entire team receives the same evaluation, whether it is a reward or punishment (Zagal et al., 2006).

Regarding the above criteria, collaborative searching presents a specific challenge: division of labor. Faced with this task, we must find a strategy that allows parallel work without affecting awareness of what others are doing. Attempting to reduce unnecessary redundancy, which is a duplication of work, users work with parallel search patterns. This can only be achieved through high coordination and awareness of teamwork (Morris, 2008).

All of this adds up to the need to develop new search models that support collaborative behaviour among users. In this way, future tools that enable the task of searching for information can be adapted transparently to the collaborative needs that users face.

2.1.2 Collaborative learning and collaborative searching

In recent years, collaborative learning (CL) environments have gained importance and notoriety, due to the contribution observed in students' education and personal formation. By collaborating with their peers, students develop important communication and social skills as they learn to carry out multidirectional dialogues and submit their ideas to their classmates' critical analysis (Nussbaum et al., 2009). Collaborative learning allows the members of a group to articulate their points of view and negotiate and exchange ideas; learning is achieved through a process of building knowledge (Infante et al., 2010; Zurita et al., 2005) where students interact with the source of information, their peers, and the teacher.

With growing Internet access in schools around the world, the Internet is shaping up to be the main source of information for students. A large part of the information searches that are carried out within schools are based on group interactions (Large et al., 2002), which is why the process of searching for information has the potential to become a powerful collaborative learning environment that is useful to the entire curriculum. Collaborative searching, by proposing interaction in a group where there is awareness of others' work throughout the entire process, allows students to share not only the results or final product of a search, but also the process that lead to those results (Twidale et al.,

1997). Cooperative searching, by merely distributing the workload, makes it easier for students to carry on using only a fragment of knowledge, that they later copy-and-paste to form a greater project; collaborative searching moves students to work together to build all the knowledge they need.

The effective integration of collaborative searching and curricular planning requires proposing search models where the user is no longer viewed as an isolated individual, but as an active member of a group. The purpose of this paper is to present a conceptual model of the process of collaborative searching that can be implemented as a structure for teaching activities that revolve around group searches for information and the collaborative building of knowledge. Section 2 presents a possible model for collaborative searching that is articulated through three levels of depth: a high level of understanding regarding the search process that each user faces (abstract model), a general structure for collaborative search activities within the classroom (macro-script), and finally the necessary considerations to implement the model in specific activities that fit the pedagogical objectives that the teacher wishes to reach with his students (micro-script). Section 3 presents empirical validation of the model, through an experiment carried out with eleventh grade students, and finally section 4 discusses the results and conclusions, and proposes possible future work.

2.2 The process of collaborative searching

The complexity of developing multiuser search models that promote collaboration among the members of a team is possibly one of the reasons that explain the lack of computational tools that help carry out this task. In order to better understand the challenge, the problem can be divided into two levels of depth: the user's experience when faced with the task of searching (abstract model) and the sequence of steps or stages that a collaborative search activity follows (script). A script structures the interaction between individuals and determines collaboration and problem solving logistics (Nussbaum et al., 2009), as well as offering detailed sets of instructions for each activity (O'Donnel & Dansereau, 1992). Scripting can be conceived on two levels: on one hand, we have the general structure of the activities (macro-script), and on the other we have the concrete steps that must be followed during a collaborative search activity within the classroom (micro-script). A micro-script is an instruction manual for

the teacher and the student that adapts the macro-script to the specific subject and context in which the activity is being carried out (Dillenbourg & Tchounikine, 2007). In order to illustrate the difference between both scripts, we can picture a game of chess. The macro-script contains the rules of the game that determine the existence of two players that face each other, the goal for each player, the distribution of the pieces on the board, the movements allowed for each piece, the structure of turn-taking in the game, etc. Then a micro-script determines the implementation of the macro-script. This micro-script changes according to the type of implementation; for example, the game can be played with a physical board and pieces, by letter, through a computer simulator, etc. While the micro-script can change drastically depending on the support tools that are used and the context of the game, the macro-script remains constant because each micro-script is still an implementation of a game of chess. This allows us to see the logic of the activities and their specific implementations, separately.

The following model is articulated on the three depth levels described above (Figure II.1). It uses Kulthau's Information Search Process as an abstract model (Kuhlthau, 2010), defines a procedural model for collaborative searching and, finally, proposes the ideas that should be considered when carrying both the abstract model and the macro-script to a concrete implementation within the classroom, or micro-script.

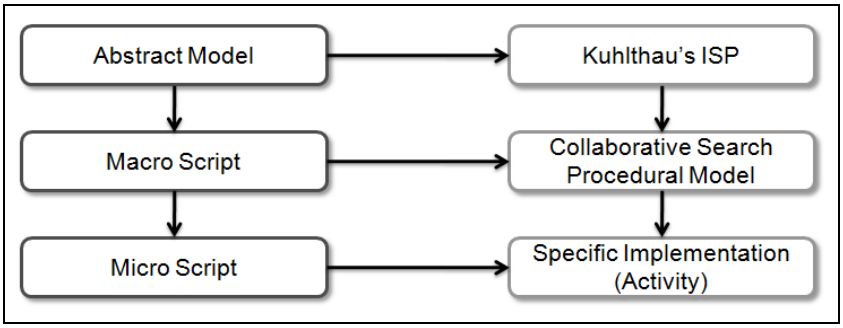

Figure II.1: Collaborative search model in three levels

2.2.1 Abstract model

The user's experience during the search task has been previously modeled by Kuhlthau's Information Search Process (ISP) (Kuhlthau, 2010). This work offers a general understanding of the different stages that a person goes through during the process of

searching for information. The ISP is the construction in which a user is submerged when he actively seeks to understand the information found within a period of time. (Kuhlthau, 2010) describes this process in six stages, as follows:

(1) Initiation, when a person senses a lack of knowledge or understanding, and feelings of apprehension and uncertainty are common.

(2) Selection, when a general area, topic or problem is identified and the initial uncertainty gives way to a brief sensation of optimism, and a desire to begin the search.

(3) Exploration, when inconsistent or incompatible information is found, and uncertainty, confusion and doubt frequently increase.

(4) Formulation, when a focalized perspective is formed, uncertainty decreases and confidence begins to build.

(5) Collection, when information relevant to the focalized perspective is gathered, and uncertainty decreases while interest and involvement deepen.

(6) Presentation, when the search is completed with a new understanding that enables the person to explain his learning to others, or put his learning to use.

Each step of Kulthau's ISP is characterized by three domains that are relevant for the user: the affective domain, which is directly linked to the emotions that are present at the time of the search; the cognitive domain, related to the searcher's thoughts and mental processes; and the procedural domain, related to the actions carried out by the investigator.

Despite the fact that Kuhlthau's ISP is based on the perspective of a single person searching for information, there are studies that show that it would be possible –without major modifications- to apply this model to a group search (Hyldegard, 2009). The ISP is an abstract model that allows us to understand the process that every member of the group will go through when faced with a collaborative search. The emotional domain makes it possible for the teacher to understand the series of feelings that will overcome his students when participating in a group task, and it allows him to anticipate actions

that will reduce the negative effects –such as the demotivation that uncertainty and frustration bring- and take advantage of the positive effects –for example, using confidence as a motivating agent. The cognitive domain makes it possible for the teacher to modify his interventions at every stage to match the state of the activity, in terms of formulation of knowledge by the students, thus facilitating the process. Finally, the procedural domain determines the conduct that should be promoted among students, whether it is exploration and discovery, or documentation and organization of information.

2.2.2 Macro-Script

In the case of collaborative search activities within a collaborative learning context, we propose a macro-script called Collaborative Search Procedural Model (CSPM). The model considers the existence of two roles: student and teacher. The student acts as a member of a search team who must collaborate with his peers, search for and contribute new information and document the search process, as well as the results. This model presents the collaborative search activity as a series of steps where the individual process that each student goes through –described in Kuhlthau's ISP- is inserted into a group dynamic where the collaborative atmosphere aims to take advantage of the interaction among peers, so as to reduce negative feelings –uncertainty, frustration, etc.- and boost positive feelings –optimism, confidence, etc. The CSPM proposes decreasing interventions from the teacher, as far as guiding the search process, so it is gradually left in the group's hands as they learn to focalize their work. In order to achieve this, the steps that are mainly exploratory are guided by the teacher, while the steps where knowledge is built and documented call for more independent work on behalf of the students.

The macro-script suggested by the CSPM proposes four linear stages: (1) Motivation and domain definition, (2) Search term selection, (3) Search and construction –made up of the sub-stages of personal search, personal build, personal discover and describe and group build- and (4) Group discover and describe. Each stage and sub-stage of the CSPM is defined by a high-level procedural description, by collaboration goals determined according to the criteria laid out in the introduction to this paper and by Kuhlthau's ISP (Table II.1).

Table II.1: Stages of the CSPM

Stage	Description	ISP Objective	Collaborative objective
Motivation and Domain Definition	The subject of the investigation, as well as its general objectives, reach and focus must be determined with the intervention of the guide (teacher). Additionally, the rules to be followed during the activity are established, such as the way in which the work will be divided, and what platform or medium will be used to build the final hand-in.	Through a proper definition of the domain, the student's uncertainty regarding the task can be reduced.	A common goal must be established for all students. Rules of coordination and communication must be determined. The common rewards that the students will receive must be made explicit.
Search Term Selection	Lead by the activity guide (teacher) the students suggest key words or queries for the group search, which are shared with all the other students. Then, from the pool of keywords chosen for the investigation, each student determines a sub-set of words that he will use in his stages of personal search. This distribution of words	Collaboration in the forming of queries accelerates their refinement, which improves the quality of the results obtained (Morris, 2008). Thanks to this, the students' optimism towards the task increases.	The collective formation of queries increases each student's awareness regarding others' work (Morris et al., 2006). By distributing queries among the students, we are creating a less redundant distribution of the work, and determining each student's individual responsibility

	determines an initial distribution of the work.		regarding the activity.
Personal Search	In this stage, each student searches for information independently –using the keywords he previously selected. Each result must be filtered, evaluated, and valued.	Each student, through his personal process, faces confusion, frustration and doubt, feelings that arise without pressure from the group or interactions to distract him. Additionally, every student must go through every stage of the ISP, regardless of the differences in work capabilities with his peers, in order to ensure that each student generates his own focus, confidence, and sense of direction.	Personal searches allow students to feel that part of the work he is carrying out is his own, increasing his perception of individual responsibility. By ensuring personal processes, we can avoid a single student taking over the work and ignoring others' work, which increases positive interdependence. Parallel work contributes to a distribution of the work without duplicates, while at the same time forcing an increase in awareness, coordination and communication.
Personal Build	The searching users (students) summarize every result that comes up through their web search. They are free to organize and categorize these summaries how they prefer, so they understand the specific contribution that this information makes to the investigation.		
Personal Discover and Describe	The student organizes his personal summary so it is coherent, and builds a macro-structure with the information, following the classification he determined in the personal build stage. In this way, he can articulate his ideas and knowledge before		

	exchanging with his teammates.		
Group Build	Using the results contributed by each member, as well as their respective summaries of key concepts, the information must be reorganized, so as to articulate the entire group's contribution in a first draft of the answer to the initial question. Group building can happen through the reclassification of group summaries under new criteria defined by the group, or by linking ideas from the summaries, so as to create a "map" of the knowledge that the group has built.	Interaction among peers can dissipate doubts and confusion among group members. By coordinating each member's contribution, a focus is established and a unified sense of direction is created. Interaction among peers validates each member's ideas, so the confidence each student has regarding his work increases. Working in a group also motivates students to search for better answers. In some cases, the opposite dynamics can present themselves, where interaction among peers increases discrepancies and conflicts emerge; this is why the teacher must monitor each stage and mediate when necessary.	The integration of each member's contribution increases positive interdependence and forces students to work in a coordinated manner. Ideas presented by teammates increase awareness regarding others' work. Building a single final presentation that belongs to the entire group –as opposed to belonging to any one student- allows students to better understand why there are joint rewards.
Group Discover and Describe	The members of the group work together to build a final answer to the question that was the object of the collaborative search. This answer includes all the angles that were studied individually, but organized in such a way as to allow the group to articulate and transfer the joint		

	knowledge. The format of this answer will depend on what was initially proposed by the guide. In this way, the final result belongs to the entire group, and not any individual member.		

The structure of the CSPM –considering stages and sub-stages- can be summarized in the diagram presented in Figure II.2

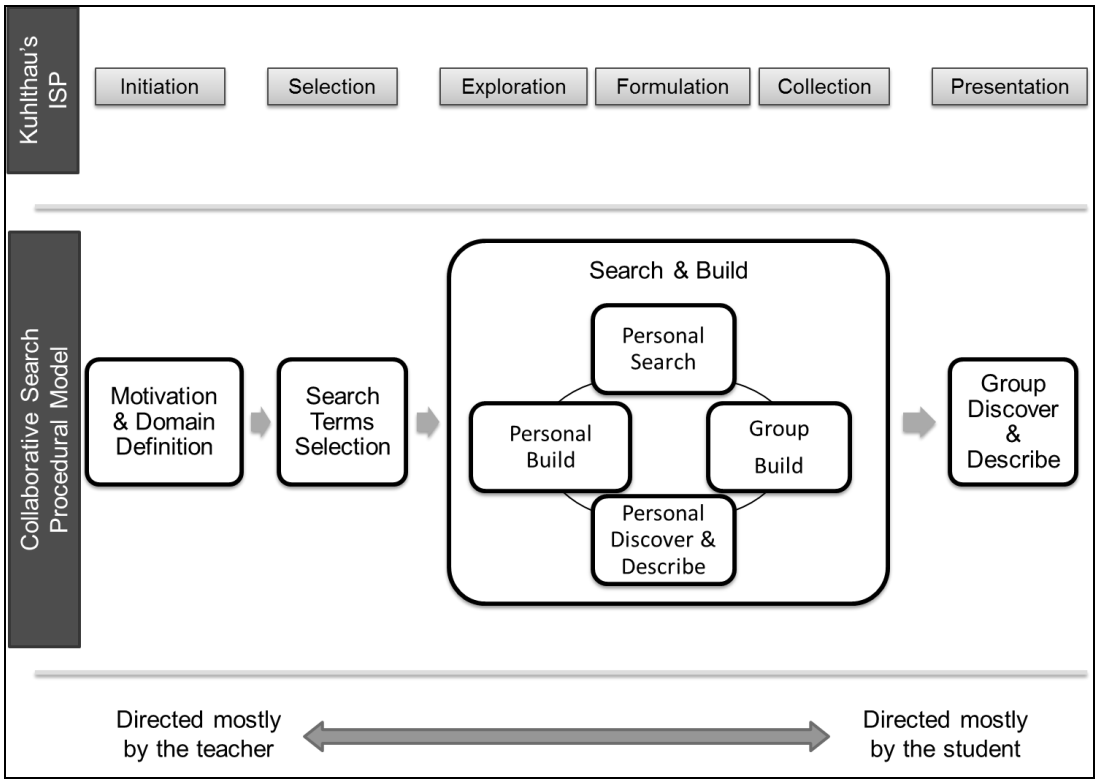

Figure II.2: Collaborative Search Procedural Model and its connection to Kuhlthau's ISP

2.2.3 Considerations for the implementations of a micro.script, based on the CSPM

The proposed collaborative search model is divided into three levels of depth so it is not tied to any specific implementation, allowing it to serve as a base for activities in any area included in the school curriculum. The shape of the micro-script will depend on the educational context, and the factors that should be taken into consideration will vary according to the specific implementation conditions. Some of the most relevant factors are:

(1) Technological support: In spite of the fact that it was designed with the Internet in mind, the CSPM can be implemented with several levels of technological integration that range from work that is totally based on pen, paper and books, to work that is completely assisted by computers (for example, building a dedicated software that integrates web access interfaces, as well as interfaces for the elaboration of medial hand-ins – text, presentations, video, etc.). The inclusion of technological tools especially designed with this purpose will make it possible to automate monitoring and controlling the rules in each stage.

(2) Forming work teams: The structure and methodology of the investigation groups affects the quality of their work. It has been determined that randomly selecting the members of each group is an effective way to achieve positive results as far as collaboration (Nussbaum et al., 2009). Regarding group dynamics, and in support of better collaboration among the members of a group, it has been observed that small groups (2 to 4 people) allow better participation for each member, obtaining consensual solutions in the development of the investigative assignment (Valdivia & Nussbaum, 2009).

(3) Type and construction of the final hand-in: The search and work dynamic will be strongly influenced by the final hand-in that is required of students. The work changes when it is aimed at an essay, as opposed to an oral presentation, video, etc.

In addition to the previous considerations, detailed instructions –or micro-scripts- must be specified for each stage, where the way in which each step will be implemented, the specific rules for each step, and the possibilities for work and interaction among the students, are specified. These instructions will establish a collaborative search activity that will be partly determined by the variables described above, but will also imply a series of design decisions, such as the documentation of the search process, the desired group work dynamics, etc.

2.3 Empirical evaluation

The main goal of the empirical work that was carried out was to evaluate if the macro-script proposed by the CSPM promotes collaboration among students. In order to do this, we used the collaboration criteria described in Section 1 of this paper. The main difficulty in evaluating the collaborative search process described in the previous section is that implementation requires a micro-script, which means it is possible to generalize the obtained results into the macro-script, but these are specific to the micro-script that was used.

2.3.1 Methodology

We worked with 24 students in the 11th Grade (Junior High School), in a private school located in Santiago, Chile, where students belong to a high socio-economic level. We worked on the subject of history, and the goal of the activity was for students to work in groups of three, and write an essay about "The characteristics of urban and rural systems".

Students were randomly divided into 8 groups of 3 students each. 4 groups worked freely, their sole limitation being that they had 90 minutes to hand in their final paper; the other 4 groups worked following the CSPM, in the same time frame. All 8 groups had the same technological support: 1 computer per member, access to a search engine and a word processing tool. All 8 groups received the same set of written instructions, which considered an introduction to the subject of the activity, the expected depth of their essays, and some basic points they were required to cover in their papers.

2.3.2 Micro-Script

For the 4 groups that worked following the CSPM, a micro-script was developed where the formation of the groups, the technological support, and the final hand-in were the same as for the other 4 groups, which worked freely.

Each group was assigned a tutor that knew the micro-script, so he controlled and guided the team as they followed the script. Each stage of the CSPM was implemented in a micro-script, as follows:

Table II.2: CSPM Micro Script

Stage	Implementation	Rules
Motivation and Domain Definition	A set of written instructions was handed out for the activity.	Each student had to read the instructions and clarify any doubts he had, prior to beginning the activity.
Search Term Selection	The students from all 4 groups worked together, guided by a teacher who asked the students to contribute search terms that they found relevant. The terms were discussed among all the members of the class, and 6 words were selected by the students, with the help of the teacher. Then, each group had to distribute the 6 search terms among its members.	Each student had to contribute at least 3 search terms. Once the 6 terms that were going to be used were selected, each group had to assign those terms to its members (2 per person), without repeating them. Each student was responsible of using at least 1 of the terms that were assigned to him in each of his searches.
Personal Search	Each student had access to a search engine and was free to build queries as he saw fit, but he always had to include at least one of the search terms that had been assigned to him in the previous stage.	During the four sub-stages that make up the Search and Construction stage, the students were encouraged to maintain constant communication among themselves.

Personal Build	When a student found a search result that he found relevant, he saved the link and made a notation on a Post-It note, summarizing the value and usefulness of the site he had found.	Each student had to have at least 5 saved results before he could begin working on the Personal Discover and Describe stage. The group outline designed in the Group Construction stage had to include at least 3 results from each member of the group. The students were free to repeat any of the four sub-stages of the Search and Construction stage, returning freely to personal search in order to contribute new results. When the students felt that their group diagram was ready, they had to show it to the group's tutor, who checked to see if they had complied with all the rules of the stage.
Personal Discover and Describe	When the students had a minimum of 5 saved results, they were asked to articulate each Post-It in a small outline, on a sheet of paper, where they explained the contribution of each result and the connections between them.	
Group Build	When the students had a small outline of their results, they were asked to share them with their peers, in order to build a greater outline that included everyone's contributions. If the group found it necessary, each member could go back to the personal search stage and repeat the 4 search stages that make up the model.	
Group Discover and Describe	When the tutor checked the outline in the Group Build stage, he randomly assigned a student to be in charge of using the word processing tool to write the team's final essay. The students had to write the essay based on the outline they had built. The students who were not designated to write had to help their teammate, and could use their computer to go on the Internet and check the information sources they had saved, in case it	The essay had to be at least one page long. The members of the team who were not designated to write the essay had to participate in the writing process, contributing information from the references they had saved. The tutor made sure that all the students participated in the final writing stage, and that the students who didn't write the text proof-read it before

	was necessary to complete previous information searches.	handing it in.

2.3.3 Evaluation

Measuring tools were the same for all 8 groups, regardless of work methodology. All the students had to take a knowledge test before and after the activity, which was designed with the help of the school's History teacher (Pre and Post Test). This test was built based on the criteria in Bloom's revised Taxonomy, which lists educational objectives in order of difficulty, and measures cognitive capacities like remembering, answering, understanding, applying, analyzing, evaluating and creating (Anderson et al., 2000). Students also had to answer a survey at the end of the activity. The goal of the pre and post test was to evaluate the learning achieved by the students, while the goal of the survey was to measure whether the participating students considered that the collaborative criteria included in the activity were met (Table II.3).

Table II.3: Evaluation of the CSPM

Criteria	Objective	Implementation and Evaluation
Common Goal	To measure the level of goal alignment regarding the work of every team member.	Questions: -How did you want your essay to be? -What did you hope to achieve with your essay? The evaluator determined if the students had the same goals regarding their work, based on their answers. A scale of 1 to 5 was used, where (1) was Not Aligned, and (5) was Very Aligned.
Positive Interdependence	To evaluate to what extent students consider	Opinion scale questions using a 5 level Likert scale where (1) is Strongly

	that their teammates are essential to reaching their goal.	Disagrees and (5) is Strongly Agrees. -Without my teammates, I would not have been able to complete this assignment. -My teammates did not contribute as much as I did to the assignment.
Coordination and Communication	To measure the level of coordination achieved within the group.	Opinion scale questions using a 5 level Likert scale where (1) is Strongly Disagrees and (5) is Strongly Agrees. - It was easy to coordinate teamwork. - Communication among my teammates was fluent. - Communication among my teammates was fundamental.
Individual Accountability	To measure the relative contribution that the student thinks he is making with his personal work, towards reaching the common goal.	Opinion scale questions using a 5 level Likert scale where (1) is Strongly Disagrees and (5) is Strongly Agrees. -Without my contribution, the assignment would not have turned out the same. -My work is reflected in the final document. -I was able to explain to my teammates what I learned during my investigation.
Awareness	To measure a student's level of awareness regarding what his teammates are doing.	Opinion scale questions using a 5 level Likert scale where (1) is Strongly Disagrees and (5) is Strongly Agrees. -I knew what my teammates were doing at all times. -My teammates knew what I was

		doing at all times. -I knew what the group was working on at all times.
Division of Labor	To evaluate if the student thinks the distribution of the work was fair and equitable.	Opinion scale questions using a 5 level Likert scale where (1) is Strongly Disagrees and (5) is Strongly Agrees. -The work was divided equitably. -Another member of my team worked less than I did.
Reduction of Redundancy	To identify redundancies in the search and in the division of labor.	Opinion scale questions using a 5 level Likert scale where (1) is Strongly Disagrees and (5) is Strongly Agrees. -My teammates and I used the same websites as sources of information. -My teammates and I used the same search queries. -My teammates and I were doing the same searches in parallel.
Joint Reward	To ensure that the evaluation of a group is the same for all its members.	Due to the way the essays were evaluated, this criterion is met because the students knew that the evaluation they would receive would be the same for all team members. Because of this, this criterion was not included in the survey.

2.3.4 Results and discussion

The results of the pre and post test (Table II.4) show that the students who worked according to the CSPM present a greater increase in knowledge thanks to the activity. This could be due to the fact that the CSPM forces students to summarize what they have

learned, and explain it to their teammates, so a real appropriation of knowledge takes place.

Table II.4: Knowledge results with the CSPM

	Pre Test		Post Test		*p-value*	Significance (Cohen's d of the difference)
	Average	Standard deviation	Average	Standard deviation		
Without CSPM	5,46	0,47	5,58	0,85	0,32	0,19
With CSPM	4,83	0,88	5,50	0,43	0,04	1,12

The results of the survey that measured the collaboration criteria can be seen in Table II.5. Generally speaking, we can see that the CSPM makes it possible to strongly increase the level of alignment of goals within work groups (Common Goal); it increases individual accountability, contributes to a better division of labor and reduces redundancy. At the same time, the implementation of the micro-script that was used worsens the criteria regarding communication within the group (coordination and communication, awareness and positive interdependence).

Table II.5: Collaboration results with the CSPM

Search Collaboration Criterion	Working Without CSPM		Working With CSPM		Significance (Cohen's d of the difference)
	Average	Standard deviation	Average	Standard deviation	
Common goal (Average: Min 1 – Max 5)	2,25	0,35	5,00	0,00	11,79

Positive interdependence (Average: Min 1 – Max 5)	4,56	0,31	4,33	0,71	-0,45
Coordination and Communication (Average: Min 1 – Max 5)	4,41	0,23	4,17	0,44	-0,72
Individual accountability (Average: Min 1 – Max 5)	3,44	0,11	3,72	0,38	1,06
Awareness (Average: Min 1 – Max 5)	4,04	0,26	3,61	0,51	-1,13
Division of labor (Average: Min 1 – Max 5)	4,44	0,44	4,72	0,25	0,83
Reduction of redundancy (Average: Min 1 – Max 5)	3,22	1,17	4,11	1,17	0,83

The increase in goal alignment that can be seen in the students that worked with the CSPM can be explained because the model forces students to work together. The tutors who supervised the students who worked without a script found that all 4 groups decided to assign parts of the task to each member, and work separately. Then, when the time came to hand in the final paper, they copied and pasted each member's part of the essay, to form one final document. The CSPM forces students to coordinate with each other regarding their goals, and to negotiate any differences that might arise.

The increase in perception of individual responsibility can be explained because, when a student who is working according to the CSPM is assigned certain search terms, he is in charge of an area of knowledge that he must later explain to his teammates and contribute to the final paper. In the work dynamics that didn't follow a script, each student worked

independently, never having to face his peers and explain the work he carried out, or receive their comments regarding his work.

The better division of labor, as perceived by the students, could be due to the fact that they can see their teammates' work, and therefore understand what their peers are doing. In the groups that worked without a script, students tended to concern themselves exclusively with their part of the work, so they were left with superficial ideas regarding what their teammates had done.

The reduction in redundancy can be partly explained by the fact that when students who follow the CSPM encounter an information vacuum corresponding to search terms that were not assigned to them, they ask their teammates for help and they teach each other. In the cooperative dynamics established by students who worked without a script, when a student faced an information vacuum he tended to solve it by himself, without turning to his teammates, which doubled the work and made them lose the possibility of collaborating among themselves.

It is interesting to note that the work following the CSPM worsens the collaboration criteria that relate to communication within the group. However this evaluation, which initially seems negative, can have a second interpretation. First of all, the positive results obtained in the evaluation of Awareness, Coordination and Communication in the case of students who worked without a script is due to the fact that they interacted with each other only at the beginning of the activity –when the work was distributed- and at the end of the activity -when the different parts are put together. Because of this, students feel that they don't have any communication problems, and that work within the group was fluent; however what is actually happening is that these students have not worked collaboratively. Students who follow the CSPM are forced to interact with each other, and so they are faced for the first time with the idea of following their teammates' work. This logically leads them to perceive that communication within the group was difficult. Also, because they were not working with tools designed to support collaboration, they were forced to interrupt each other, which was also perceived as a communication problem.

The decrease in the evaluation of positive interdependence when we compare free work with work done following the CSPM can also be explained through the perception that

students have of collaborative work. When working without a script, students write paragraphs for the essay, and then copy and paste them with minimal modifications. This means that, when they look at the final paper, they can identify the parts that were done completely by them and those that were done completely by their teammates. The students that followed the CSPM couldn't recognize their contributions to the essay, because everything was built as a team; because of this, and because of the fact that they understand the logic of the complete assignment, most of them feel that they could have finished the assignment by themselves –without realizing that the reason they understand the complete assignment is that their teammates taught them during the activity, and they learned from their peers. This is also connected to the increase in the results of the pre and post test in students who worked following the CSPM.

What these results show is that cooperative work habits are deeply ingrained in school work, and that collaborative work logic breaks the traditional process students follow when they work in a group. Under collaborative work models, students interact more among themselves, and exchange knowledge, which is something they are not used to doing, even though group work is an everyday reality in schools.

2.4 Conclusions and future work

The tools we use today to search the Internet do not offer the possibility for groups of users to work collaboratively at the task of searching. However, it is common for this activity to be carried out by a group of people. Specifically in the case of educational contexts, group work is a daily reality; however the lack of tools that support the collaborative search for information implies a loss of the richness that collaborative environments bring to the classroom.

The first step in the development of tools that foster collaborative work in the search for information is to propose abstract models that consider the user as an active being within a group of individuals faced with a common search task. The articulation of Kuhlthau's ISP with the macro and micro-script structure proposed through the Collaborative Search Procedural Model is an initial approximation to collaborative search tasks.

The empirical evaluation of the CSPM allows us to understand the contribution of the model to collaborative dynamics within the classroom. Extensive opportunities for future

work lie in proving the effect that different micro-scripts have on student's effective learning.

The experimentation presented in this paper shows the preponderance of cooperative habits over collaborative ones when having to work in a group within the school world. The great challenge that remains will be to promote tools that make it easier for students to work collaboratively in group investigations; in order to achieve this, future work must develop a software tool that follows the CSPM and a proper micro-script, making it possible to foster collaboration among students. The tool that needs to be developed must implement non-invasive communication methods among the members of a group, and allow for the awareness of others' work to occur without interrupting them. This will improve the collaboration criteria that yielded negative results in this first evaluation.

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A P P E N D I C E S

APPENDIX A: PAPER RECEPTION LETTER

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