DESIGN OF A MICRO SCRIPT OF COLLABORATIVE SEARCH FOR EDUCATIONAL PURPOSES AND ITS IMPLEMENTATION THROUGH A COMPUTATIONAL TOOL

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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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© MMXI, Daniela Albornoz
(To my family and my loved ones,
thanks for the unconditional support.
Always for you, Mom.)
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ABSTRACT

Searching online is one of the most powerful resources today’s students have for accessing information. Information searching online in groups is a daily practice across multiple contexts and different purposes; however, traditional search models take into consideration a single user navigating online in solitary. This has brought that the tools we use for searching and subsequent outcome consolidating do not allow for collaborative practices. In previous work, we developed a three level conceptual model that enables the implementation of collaborative search classroom activities. This study presents a software solution, CollSearch, which follows the Collaborative Search Procedural Model (CSPM) and presents a unified tool that enables collaborative searching computer-supported classroom activities.

Empirical evaluation of proposed software shows considerable improvements regarding the students’ learning outcome. The results –measured through usability, collaboration and learning criteria– show that use a collaborative-oriented application can achieve better results for the student's education than those achieved using traditional applications.

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

Keywords: collaborative learning; collaborative search; computer-supported classroom activities; information search; search engine
RESUMEN

La búsqueda en línea es uno de los recursos más poderosos que los estudiantes de hoy tienen para acceder a la información. La búsqueda de información en línea en grupos es una práctica cotidiana en múltiples contextos y con diferentes propósitos, sin embargo, los modelos tradicionales de búsqueda consideran un solo usuario que navega en línea de forma solitaria. Esto ha provocado que las herramientas que utilizamos para la búsqueda y posterior consolidación de resultados no consideren prácticas de colaboración. En un trabajo anterior, hemos desarrollado un modelo de tres niveles conceptuales que permite la implementación de actividades de búsqueda colaborativa en la sala de clases. Este estudio presenta una solución de software, CollSearch, que sigue el Modelo Procedural de Búsqueda Colaborativa (CSPM) y presenta una herramienta unificada que permite actividades de búsqueda colaborativa asistidas por computadora en la sala de clases.

La evaluación empírica de software propuesto muestra mejoras considerables con respecto al aprendizaje resultante de los estudiantes. Los resultados – medidos a través de criterios de usabilidad, la colaboración y el aprendizaje– muestran que el uso de una aplicación orientada a la colaboración puede lograr mejores resultados para la educación del estudiante que los obtenidos usando aplicaciones tradicionales.

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Palabras claves: aprendizaje colaborativo; búsqueda colaborativa; actividades de la sala de clases asistidas por computador; búsqueda de información; motor de búsqueda
1. INTRODUCTION

1.1 Motivation

There is no doubt: technology and especially computational tools can be very helpful in resolution of different tasks they perform every day in civilized society. For those who have deepened our studies in the fields of Information and Communication Technologies (ICT), we have strong intuitions that technological advances can be transformed in easier performing tasks, more efficient processes, more effective results and higher capacity to generate, store, transport, communicate and correctly use information.

The information and communication technologies are not panacea or magic formula, but can improve the lives of all inhabitants of the planet. They have the tools to reach the Millennium Development Goals, of instruments that will advance the cause of freedom and democracy, and the necessary means to spread knowledge and to facilitate mutual understanding.

(Kofi Annan, Secretary General of the Organization of the United Nations, inaugural speech of the first phase of the WSIS, Geneva 2003).

However, history teaches us quite the opposite, since in fields where ICT could have major impact on disseminating information – Education, Department of Justice, Government Entities, Health Services, Social Projects, Culture Education, to name a few– is where we see less technological inclusion and greater resistance to any change of this type. And with good reason, because it is precisely in those fields where any mistake can be highly expensive or even irreparable.

Unfortunately, technological innovation is known by a highly troublesome beginning, that must be fixed up in implementation and use through a process of trials and errors – which may take even as long as the applications lifetime–. In addition to the above, there
are a large number of constraints hindering expansion of information technologies –such as technical and security issues and cultural and economic barriers– which finally difficult diffusion of these tools in all activities.

One thing is true; the global evolution requires massive use of ICT. The requirements on handling and sharing information are present across all areas and among different stakeholders.

This is why, given the above evidence, professionals of Information and Communication Technologies should seek ways to bridge the gap between tools they present and utility that end-users able to take advantage, through a greater understanding of developers should be about users.

In this study, main focus is educational field. Particularly, in this area is where there is an incipient technological inclusion with very low impact, recently driven in the last years. However, given the education’s nature, information management becomes critical so stakeholders –from ministers and supporters to the students themselves–, who have made use of broad spectrum technological tools that do not meet educational needs, looking for some way to amend current requirements. This subsequently result in inefficiencies related learning processes and work overload for involved users.

The specific motivation is to satisfy the pedagogical requirements that occur inside the classroom, which mostly could not have been properly satisfied, through inclusion of technological tools to provide management and communication of information.

For successful incorporation of any technological innovation that support education, we must be concerned about all interactions that arise on student activities and hold work flow properly, to keep the realness of it without adding extra effort. For this reason is necessary establish a pedagogical model to be incorporated as a logic main source of any
computational tool. In other words, we should guide the development of technological applications to design particular activities with specific pedagogical objectives that properly responding to required interactions and real needs, rather than keep focus of designing multipurpose tools or many self-contained features, which usually involves implements that not satisfy all users’ needs and therefore are not used.

This study focused on group activities as complementary support for the learning of knowledge. Among these activities, the information searching in groups is very interesting because is a process that involves high complexity and a large number of interactions for participants, which are currently not regarded in any tool useful for this assignment. Today, a task like this involves a high coordination between the members of working group and large consolidation skills, often exceeding capacity and experience of student as team search process managers. In these commons situations in the school stage exists a clear need for a specific tool to back up student learning through the search process, strengthen collaboration at every step and facilitate training of each member to work in group.

1.2 Hypothesis

We suggest the importance of tying technology development to identified needs in educational environments, taking into account both users and learning process’ interactions, to deliver technological tools of real support to school assignment of information searching in groups. For this, we propose the design of applications focused on procedural models, which serve as Macro Script (Dillenbourg & Tchounikine, 2007) able to detail interactions between participants and meet specific needs of included tasks. In this case, we require a pedagogical model that incorporates educational objectives and multiple interactions and complexities of information searching in groups, which can describe all needs that specific applications must satisfy. With these considerations, it is
possible to develop high-impact technological tools that fully meet users’ expectations, achieving greater value through technology.

This study proposes that a technological application tailored to specifications for a collaborative assignment with educational purposes allows improve the results in the learning of students –understood as the new knowledge acquired by each student individually along the process– and facilitate teacher’s supervisor labor, in comparison to results achieved without this process-oriented tools; so might conclude that the inclusion of specialized-oriented technology is favorable for progress in fields of education, under conditions that current technology cannot adapt to particular needs of this area. For this, we must use a procedural level pedagogical model to understand educational objectives of school activities, process of knowledge formation and rules required to ensure an appropriate work flow.

1.3 Objectives

The aim is to demonstrate all benefits that can be achieved by using a dedicated tool oriented to support school activities of information searching in groups for pedagogical purposes, provided that users and their interest are the main part of the application design.

To this, we use the Collaborative Search Procedural Model (CSPM) as base model, because it describe multiple interactions that should be take into account for achieve a correct information searching in groups activity –from an academic point of view–, including both learning objectives and collaboration within the group. The CSPM defines seven stages that regulate and clarify the process, plus eight search collaboration criteria for guiding work to collaboration’s learning objectives. In our previous work (Verdugo et al., Submitted for publication), we showed that CSPM is very effective –
from a pedagogical point of view, in acquisition of individual knowledge—when using it to design and regulate a process of information searching in groups, but technological support—using software designed for interactions defined therein exclusively—is a critical requirement to achieve better results in individual knowledge acquisition and collaboration in the process.

Furthermore, to ensure the proposed computational tool is helpful for users and does not introduce more complexity to information searching in groups process, we seek high result of application’s usability, for which Nielsen Usability criteria were assessed: Easy to Learn, Efficient to Use, Easy to Remember, Few Errors and Subjectively Pleasing (Nielsen, 1994).

1.4 CollSearch – Implementation of the CSPM

In consideration of above, we developed a specific tool to support activities of information searching for pedagogical purposes, which aims to substantially improve experience of those involved—mainly students and teachers—and demonstrate the value that technology may add in educational field, provided that all variables involved are properly incorporated: users, task and context.

For this reason, we regard the Collaborative Search Procedural Model or CSPM (Verdugo et al., Submitted for publication) for software design, which proposes a process with clear stages and workflow-oriented educational purposes, thus forming a theoretical framework for the activities of information searching in groups.

Because CSPM offers a Macro Script for collaborative search process to be used in educational purposes activities of information research and analysis within groups of
three students, it is necessary to define a base activity or Micro Script that instantiates the model and is used for application design (Dillenbourg & Tchounikine, 2007).

For this, we deem seven stages that CSPM raises: (I) Motivation and Domain Definition, (II) Search Terms Selection, (III) Personal Search, (IV) Personal Build, (V) Personal Discover and Describe, (VI) Group Build and (VII) Group Discover and Describe. These stages define three types of fundamental interactions: user’s personal work, user’s shared information and group’s shared work. In addition, we allow for interaction of a supervisor role that regulates the activity and monitors process.

Besides the seven previous phases, Macro Script proposes eight collaboration criteria that must meet to ensure a correct collaborative process among students, which are: Common Goal, Positive Interdependence, Coordination and Communication, Individual Responsibility, Awareness, Division of Labor, Reduction of Redundancy and Joint Reward (Verdugo et al., Submitted for publication).

With considerations previously detailed, we raised a Micro Script that particularly suited to an instance of the CSPM, the interactions required and criteria set out above, which can be seen in detail in Section 2.2.1. In this script, two roles that interact and interspersed their participation along process are detailed: the student and the teacher; in addition to a series of advancement rules that allow to concretize the Macro Script and ensure correct work flow through proposed stages in the CSPM. Subsequently, we developed Micro Script-based CollSearch application that fully implements the scheme of interactions therein detailed and it is divided into two tools that aim to satisfy separately needs of different roles: CollSearch Student and CollSearch Teacher.
1.4.1 CollSearch – From abstract models to virtual objects

In order to transform the CSPM to practical application, we introduce multiple objects and terms that allow a simple representation of collaboration and knowledge construction concepts, providing even more usability. Listed below are those concepts with a brief explanation:

- **Study Topic**: refers to assignment academic purpose. Represents the domain’s name that will be investigated through activity on Internet. Topic is set by the teacher.
- **Personal and Group Search Terms**: key search words used to navigate on activity’s topic. Search terms are tools that allow students to find information on Internet, setting the limits of study topic. Because this, at group level, search words should be enough to allow groups to explore the entire domain and to collect fully information; while, at personal level, a right terms assignment allow to segment the study topic into sub-areas that each student should research independently.
- **Web References**: web pages that user finds useful for the study assignment; i.e., a site containing relevant information to search topic. Web references save web site address and user-added information –like brief page description and personal content assessment–, providing personalized value to web content. In addition, web references store the search query used to reach that page.
- **Notes**: synthesis of information that each student brings to his group, based on web references content. The notes are information that user processes and selects as relevant to investigation (Verdugo et al., Submitted for publication), so once created are available for the rest of group and therefore anyone can edit its content or writing comments on enabled comment section. To promote synthesis of content by the student, notes only allow a maximum of 140 characters –like a
tweet-post–, pushing students to condense relevant information. The notes are considered property of the entire group, so it can be modified by any member but, if a student wants to remove them, most of group must agree with that action.

- Virtual Work Table: object that helps to share knowledge within the group. Represents a table in which all members show their notes to rest of group. With aims to achieve a similar real-table interaction, notes are located “on” this object and can be moved freely in it, to facilitate formation of mental knowledge models.

- Final Document: the result of investigation assignment: an essay or document containing all collected information. This document is edited by only one student at a time, randomly selected.

### 1.4.2 CollSearch – Implementation of flow process

The following section shows how applications take the Micro Script detailed in Section 2.2.1 and reflect it in different tools, separated in the student and teacher roles. In this, we exhibit different interfaces of the application, showing the high cohesion existing between Macro Script used as base –inspired by the CSPM–, the Micro Script that specifies an instance of this and the proposed tools –CollSearch Student and CollSearch Teacher–.

a) Stage I: Motivation & Domain Definition

This stage mainly takes into consideration the action of the teacher, who introduces topic of investigation, explaining its general objectives, its reach and focus, and defines the parameters of activity.
Because of this, teacher’s tool contains functions that allow him starting the activity. Figure 1-1 shows the entry of activity parameters to be made by the teacher to start a new group work. This process consists mainly of two parts: entry of parameters for activity (left side of image) and the formation of groups of three people randomly (right side of image).

For its part, the student is only an observer at this stage, so does not have specific functionality through its application.

Figure 1-1: CollSearch Teacher: entry of parameters and group formation
b) Stage II: Search Terms Selection

At this stage, both student and teacher roles are active participants: first, student should propose search terms for the activity, then teacher filter and select from all search terms proposed for students and, finally, the student retake the protagonism and select the terms that will use along the activity, always in coordination with the members of the group.

In Figure 1-2 we can see features enabled for student at this stage: in left side of image is the view that allows users to propose Search Terms about the topic of question, and can even test effectiveness of each one in search engine provided. In right side of image is the process of selection of Search Terms, which shows terms approved by the teacher to conduct a proper investigation to the student. Stresses that, at this stage, user has chat enabled in the application, which allows him to connect with the rest of his group.
On the other hand, Figure 1-3 shows the function that teacher tool provides at this stage, which understands teacher’ work as a guide for students’ work. In this image are stacked different proposal submitted by students anonymously, allowing the teacher to add more Search Terms in case that deems it appropriate. He must then select, from all these options, a set of terms that will be sent to students, for the subsequent selection.
c) Stage III: Personal Search

At this stage, the main protagonist is the student, who must perform various tasks required for the process to reach the deliverable of the activity: the group essay. The teacher, meanwhile, becomes a caretaker of the process which monitors the work of groups and their members. Because of this, the teacher has different functions through CollSearch—that will be analyzed later—to facilitate its role of watchman.

Regarding to work of personal information search that should make the student, CollSearch Student application has a search engine and the list of Search Terms selected earlier—in the box “My search terms”—as can be seen in Figure 1-4. For each result returned by the browser is available the “Add” option, which allows to store the site as a
web reference. On the left side of screen are stacked the sites that the user want to store, where he can add custom information to the reference.

Figure 1-4: CollSearch Student: Personal Search

d) Stage IV: Personal Build

In the fourth stage, the student can review and summarize the information found previously in his own words. For this, we include a feature to create small notes about the web page content. Figure 1-5 shows what corresponds to the formation of notes. To create a note, the user must visit one of its web references already saved, where a box in the right side is available where he can enter the note content.
In this stage, the student can organize the notes created before in order to form a coherent schema that represents the information collected by him. Due to similarity with the next stage of the process, both phases are summed up in a same functionality which can be seen in Figure 1-6: the virtual work table.
f) Stage VI: Group Build

At this stage, the idea is to bring together the result of all students for each group—which is represented in notes—and reorganize the content to entwine the information that each member contributes to form a collective whole of consistent and unified information.

Figure 1-6 shows the Team Table, where personal notes are sent once they are created by the students (in Stage IV). In this interface, users can develop phases V and VI of the CSPM. To assist the internal organization of the working group, the notes have different colors depending on who is the creator user. Additionally, students in the group can add graphics to facilitate the formation of information schemes to facilitate both personal and group learning phase.

![Figure 1-6: Virtual Work Table (Personal Discover and Describe; Group Build)](image)
Given that the stages III, IV, V and VI of the Macro Script belong to an iterative subprocess in which the user goes from search to construction and back several times (Verdugo et al., Submitted for publication), in the student application are available simultaneously all the Search Engine, the saved web references and the Virtual Work Table –corresponding to different sub-stages features–. This can be seen in detail in Figure 1-7, corresponding to a magnified image of the top of the screen.

Figure 1-7 – CollSearch Student: Implementation of the iterative sub-process

As we can see, from this phase the user has the “My References” (1), “My Teammates” (2), “Virtual Group Table” (3) and “Instructions” (4) options, allowing him to move freely between the different stages in addition to keeping information accessible. After accomplish the advancement rules required, the “Document Group” (5) option is enabled, corresponding to the seventh stage of the CSPM: Group Discover and Describe. With this, certain minimum linearity is given to the process, but allowing the student to return previous stages –any Personal Search (III), Personal Build (IV), Personal Discover and Describe (V) or Group Build (VI)– naturally and without going back on the progress made in each stage.

g) Stage VII: Group Discover & Describe

Stage VI of Macro Script, which corresponds to the end of the process, refers to the making of the final essay. In this, the working group of students is divided between those who reviews the document and who writes it. For this reason, the student
application allow for the use of two views, as shown in Figure 1-8: in the left side, we can see the ‘Writer view’, who edits the document using the notes found in the Virtual Group Table; while, in the right side of image, we can see the ‘Reader view’, who reviews what the writing user is doing and can help in the editing through comments and corrections.

Figure 1-8: CollSearch Student: Group Discover and Describe
Figure 1-9 shows the different functions that facilitate the teacher’s supervisor role. In the top of image is found the summary information on the number of web references and notes that carries each student. In the middle of the image, the teacher has the option to access the activity’s event log, corresponding to the detail of the chat conversation and all web references, notes and essay information. Finally, in the bottom of image we can see the feature that allows the teacher to review the documents’ progress and assign it an evaluation when they are finished. These functions are available from Stage III of the Macro Script (Personal Search) to final stage (Group Discover & Describe).
Figure 1-9: CollSearch Teacher: Groups monitoring tools
1.4.3 CollSearch – Implementation of the process requirements

As we mentioned previously, Macro Script used proposes, in addition to seven progress stages, eight collaboration criteria that must be met to ensure the success of a collaborative activity (Verdugo et al., Submitted for publication).

To validate the requirements established by the CSPM, presented below are the criteria proposed for collaborative search and how these are applied at both the Micro Script proposed as the application itself.

Table 1-1: Collaborative search criteria in practice

<table>
<thead>
<tr>
<th>Criterion</th>
<th>How is it achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common goal</td>
<td>The proposed activity culminates in the development of a final document, common to all the members of the group, which indict the efforts of the group member to achieve an appropriate work.</td>
</tr>
<tr>
<td>Positive interdependence</td>
<td>Due to the forced division of labor because the search terms, together with the advancement roles, it is necessary that all team members contribute with their work to successfully complete the activity, so even the fellows would encourage those who do not are working hard enough.</td>
</tr>
<tr>
<td>Coordination and communication</td>
<td>For synchronous and face-to-face approach, communication will be most directly with between partners, rather than through the application. However, CollSearch Student contains intragroup chat that allows free communication between peers. The program also encourages coordination through the advancement rules and division of labor mechanisms.</td>
</tr>
</tbody>
</table>
**Individual accountability**

Individual accountability is achieved by identifying what each group member contributes. For this reason, use colors –green, blue and red– to distinguish each user and their individual work into the group. However, this does not happen in the second and last stage of the process: in Search Terms Selection, the proposal is anonymous so students have the freedom to fail without penalty; while in the final document the CSPM seeks to identify this product of the entire group as a whole, without distinction of each part.

**Awareness**

Awareness is achieved by providing information about what is doing the rest of the group to each user, for which the application provides views of information about the progress of the peers, in addition to shares views – the virtual work table and final document edition–, where we can see the progress of the group as a whole.

**Joint reward**

The reward of an educational activity is related to evaluation achieved for the requested outcome. In this case, the activity takes into account a common outcome for the group so the associated assessment is inevitable joint.

**Division of labor**

The division of labor mechanism mainly used is ‘divide and conquer’, by partitioning the exploration domain through the equitable allocation of search terms. In addition, advancement rules and activity parameters allow balancing work within the group.

**Reduction of redundancy**

Properties such as division of labor, high communication and coordination and awareness among group members involve a reduction in redundant work (Verdugo et al., Submitted for publication).

---

Figure 1-10 shows the CollSearch Student features that facilitate properties such as awareness among group members, coordination and communication. In the top of image we can see web references stored by the user, containing the link to access the web site, specific description, personal assessment and the query used to find the page. The
bottom of image shows web references that have stored other peers, being able to review the personalized information that they previously added. Finally, we can see that in all students’ views is available chat feature, at the bottom, which facilitates communication within the group.

Figure 1-10: Awareness, coordination and communication mechanism.

Given the previous evidence, the proposed script corresponds to a first approximation to a particular educational activity that satisfies all collaboration criteria along the team
search process, specifically adapted to the requirements and considerations set out by the CSPM.

1.4.4 CollSearch – Software architecture

Due to specifics system requirements, the system was divides into three major projects, which were developed separately and independently: on one hand are the interaction applications, corresponding to (1) the student application and (2) the teacher application; while (3) the server is concerned to communicate to all system users and back up information using log files. The three together follow a Client-Server scheme, where student and teacher applications belong to the Client layer.

Microsoft Silverlight Development Platform, version 4.0, was used for develop CollSearch Student and Teacher tools, because it offers facilities to improve the user interactive experience in web applications through multimedia, animations and high computer graphics; that are of great importance in young-oriented tools. On the other hand, for development of the server is used Microsoft API (Application Programming Interface acronyms) that facilitates generations of service-oriented applications, Windows Communication Foundation or WCF; because this application is mainly a data storage service, which first applications request to store certain information or to return any value. The connection between the different terminals is performed via the Internet, without requiring that PCs belong to same LAN. The communication logic between applications and the distribution model can be seen more clearly in Figure 1-11.
With regard to the development logic, in each applications used Model – View – Controller architecture pattern (or MVS for its acronym), which proposes to divide software into three layers that operate in isolation. As a result, the pattern decouples business logic of processes logic and user interface communication. The usefulness of each layer is detailed below:

- The model layer has a representation of all information to which system operates; that is, data and business rules for particular task. This layer is responsible for accessing and modifying databases, according to defined rules.
- The view layer can present the model in a suitable format to facilitate user interaction with information. It also defines what users can do on the model data.
The controller layer modifies the view and the model layers, responding to events triggered in both. In this way, it manages communication between the layers above. It also interacts with any other resources necessary to complete the view.

The MVC pattern can be seen more clearly in the following diagram (Figure 1-12), and later the Figure 1-13 shows how was organized this pattern in the projects development.

Figure 1-12 – Model – View – Controller architecture pattern
Finally, with respect to data scheme, we decided to use XML databases (for eXtensible Markup Language). This is in view of limited resources—both hardware and software—that most schools in the Chilean reality have at their disposal. In this way, the server application, which is concerned with backing up all data in XML files, can be placed on any computer that meets the minimum hardware requirements; and the number of students connected is mainly restricted to ability of Internet connection available. Meanwhile, the applications of student and teacher, in addition to server requirements, need previously installed Silverlight plug-in, as well the desired application—student or teacher—.

The XML files that are created for each activity in CollSearch are:

- Chat-Log, record where all conversations of student within their groups are stored.

Figure 1-13 – Application file structure
• Student-Log, records of all events associated with a student, such as saving web references and saving notes. No content is stored for any element, only the events associated.

• Student-Group-Log, record of events at group level, similar to previous record but also saving group level events such as the edition of the document. Again, no content is stored for any element, only the events associated.

• Data-Log, record of all data in the activity. This file, updated when the teacher says, back up all information about the current activity, formed groups, participating students and their stored information –contents of notes, web reference and essay–.

1.5 Evaluation

We perform three different work sessions that allowed comparing –via collaborative search, usability and quality of work criteria– the strengths and weakness of using a specialized tool for activity versus traditional applications that most users know. The three sessions consisted in:

• Users follow the proposed Micro Script using classical tools of groups’ homework, such as text editors, social networking, web browsers and chat engine.

• Student use CollSearch specialized applications to do the job, which imposes implicitly the scheme based on the CSPM.

• Student use CollSearch and are evaluated, subsequently to first trial use of the tool which aims to familiarize them with different features.
Detail of assessment—all, the methodology used, observed users, working conditions and method of data collection—and result can be found in Section 2.3.

In what concerns to specific objectives of this study, assessment allows to demonstrate that a specialized tool improves achieved result and user experience—understood as the collaboration achieved in activity and usability experience through the application—, especially if users previously know this tool, its features and capabilities in detail. In other words, when students are confronted to the tools for the first time they are not able to take advantage of full features that it provides. However, the evaluation showed that a first trial exposure to the application, in practice mode, it was enough for in a second use the students achieved better result regard to a pedagogical approach—considering both learning new knowledge and collaboration along the process—and feel more comfortable using this new application.

From this we can deduce that CollSearch, due to complexity of proposed Micro Script, is not quickly understood by users. However, enough with just one training session so they can take advantage that a specialized application represent, in this case, for the school information searching in groups.

That we observed in the three experiments, we emphasize that in both experiences with CollSearch users know that users know the process that they are following, understand it most, approve the stages and rules proposed it and even enjoy the activity. However, they cannot initially recognize all the features included in application to facilitate their work; in some cases because they do not know these possibilities or in other cases because they do not understand it or believe in the value added of these.

By including a first session of testing not evaluated with the tool, users break the tradition of using only what they know and explore different features included, allowing them to determine the usage that best suits their goals.
1.6 Conclusions

It is a fact that technology advanced and is becoming more necessary in different areas of human development, even with many barriers that exist for it.

This study shows that a specialized application can be transformed into real benefits for it users. In this case, an application to support information searching in groups allowed strengthening student abilities in acquitting knowledge and collaboration, improving their understanding of process and providing tools to improve it.

However, it is clear that benefits are not inherently in use of technological tools, it is necessary they focus on real users’ needs facing a particular task in a particular context, for which software engineers must redefine their development process and fully comfort to models that detail flow of interactions and the constraints introduced with them.

In this case, CollSearch software is absolutely based on the CSPM, implementing a high-level model and making explicitly but transparently a set of advancement rules that allow empower learning and collaboration of students across the information searching in groups assignment.

Notwithstanding the above, it is obvious that using a development approach based on procedural models to define in detail different interactions to be regarded, we introduce new variables that should be incorporated for a successful use of the tools. In particular, this study has revealed the need to familiarize users with the application’s base model so they can absorb it and even appropriate it. In other words, users should be aware of Macro Script that defines the workflow through application so that they understand different stages that are part of process, objective of each one and how this can be achieved through tools that technology presents. It is also necessary to manage
complexity introduces by a software, not only enhancing usability of the same, but also allowing users to freely explore it to learn how to use it better.

Along with this, it is imperative balance the initial basic scheme with in reality it can be achieved. While the CSPM is complete with respect to workflow, is necessary to add additional restrictions and greater complexity to reach it an automatic process, which may undermine efficiency of technology integration in different application areas. In particular case of the proposed instantiation to CSPM, we had to add four advancement rules for the workflow so it fits the process detailed on Macro Script. In consequence of the above, we should add flexibility to reach a more fluid and natural user experience through the tool, which mainly involved deliver to user the possibility to break some advancement rules and go back in workflow.

Challenge is clear: those who are dedicated to technological development must take into consideration psychological and socio-cultural difficulties that slow down innovation progress. For this, it is necessary become part of the process of developing and implementing new considerations to enhance the application design and properly meet the needs of the users and the working environments. This study demonstrates that the use of procedural models –which provide a better understanding of working ways that arise during information searching in groups as education activity– enhances the benefits delivered by applications that focus design on such information.

Technological tools have the ability to create value for user, but no for themselves. They should be accompanied by considerations in design, implementations and subsequent use of them to provide user a high quality experience and efficiency.
2 COLLESEARCH: A COLLABORATIVE SEARCH TOOL FOR COMPUTER-SUPPORTED CLASSROOM ACTIVITIES

2.1 Motivation

The use of information and communication technologies (ICT) has become more and more common in education and their incorporation into educational policies has increased (Moonen, 2008). This tendency, along with the widespread use of the Internet, leads to students seeing the web as one of the most important sources of information at their disposal, with group searches being one of the most common practices among students (Large et al., 2002). However, in spite of the fact that group searching is part of students’ daily reality, there is no massively used technological tool to adequately support this activity (Morris, 2008).

Twidale et al. (1997) proposes that social interaction is an important part of searching for information on the Internet, and that it requires explicit computational support. Search tools for the Internet are based on a model conceived around a single user who interacts with a web interface by himself (Broder, 2002). Today there is a need for web search models that consider interaction between several users, so as to foster collaboration among them. This would benefit group work, not only by allowing better coordination among the members of a group, but also by encouraging collaborative group work dynamics. In our past work (Verdugo et al., Submitted for publication), we presented a model with three levels of depth (Figure 2-1) that allows for the implementation of collaborative search activities within the context of collaborative learning environments. This model is made up of a high level idea of the user’s experience when faced with the search task –given by Kuhlthau’s Information Search
Process, or ISP (Kuhlthau, 2010) – and a duo of scripts that give structure to the activity. The creation of two scripts – one of them high-level, or Macro-Script, and the other specific to each activity, or Micro-Script – allows for the conception of a general model that can be used throughout the entire curriculum for collaborative search activities, because it can be personalized to fit the specific needs of each implementation. The first script is a general model called the Collaborative Search Procedural Model, or CSPM (Macro-Script) which proposes a high level conception of each step of the activity. The second script (Micro-Script) is a version of the CSPM that is specific to the activity that is to be implemented; this makes it possible for the model to be flexible in terms of areas of application, technological support, etc.

![Diagram](image)

**Figure 2-1:** Collaborative search model in three levels, where Kuhlthau’s ISP is articulated with a duo of scripts (Macro and Micro Scripts)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>ISP Objective</th>
<th>Collaborative objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kuhlthau’s ISP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macro Script</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborative Search</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Implementation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Activity)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**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.

<p>| Search Term Selection | Led 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 determines an initial | 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 |</p>
<table>
<thead>
<tr>
<th><strong>Personal Search</strong></th>
<th>Distribution of the work.</th>
<th>Regarding the activity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>In this stage, each student searches for information independently—using the keywords he previously selected. Each result must be filtered, evaluated, and valued.</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td><strong>Personal Build</strong></td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td><strong>Personal Discover and Describe</strong></td>
<td>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</td>
<td></td>
</tr>
</tbody>
</table>
personal build stage. In this way, he can articulate his ideas and knowledge before exchanging with his teammates.

| **Group Build** | **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; | **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** | 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. | The members of the group... |
Discover and Describe

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.

This is why the teacher must monitor each stage and mediate when necessary.

In our previous work (Verdugo et al., Submitted for publication), in addition to presenting the model described above, we carried out an empirical evaluation of the CSPM, so as to validate its effectiveness. The main conclusion we reached was that there is a need for the implementation of a dedicated computational tool that adapts to the model and facilitates the process of collaboration. This would make it possible to automatically follow a specific micro-script without the overhead that comes with controlling the script manually, as well as implementing communication systems that allow the members of a group to better interact among themselves. This paper uses this need as a starting point and presents the implementation of a computational tool destined
for pedagogical use, which allows collaborative search activities that follow the CSPM and a specific Micro-Script. Section 2.2 presents the implementation of a software tool called CollSearch, which was developed from a specially designed Micro-Script that allows collaborative search activities following the Macro-Script defined by the CSPM. Section 2.3 presents the empirical evaluation regarding usability, collaboration, and the investigative results obtained from deploying the CollSearch tool in a real scenario with students. Finally, Section 2.4 presents the conclusions drawn from this experience and the possibilities of future work.

2.2 CollSearch, a computational tool based on the CSPM

The CSPM proposes a schoolwork situation where a group of students can investigate a certain subject assigned by their teacher, and then collaboratively build a final hand-in which, in document form, exposes the information they found, in their own words. The first two stages of the CSPM, which are mostly directed by the teacher, present the topic and divide the work among the members of each group. The following three stages are individual investigation phases, where the student finds information that is relevant to the topic, builds his own point of view and knowledge on the matter and prepares to share his results with his teammates. The final two stages allow students to exchange knowledge –fostering learning among peers– and work together to build a final hand-in containing ideas proposed by all the members of the group.

The implementation of the CSPM in a computational tool requires the elaboration of a Micro-Script that applies each step of the Macro-Script in a concrete sequence of activities. It also requires a communication and interaction model that allows the members of each group to interact among themselves, while the teacher monitors each group’s advances.
2.2.1 Micro-Script for CollSearch

Because the CSPM is a Macro-Script, it can be applied to many different scenarios and its application to a Micro-Script requires a determination of the scope of the work that is expected of the students. CollSearch’s Micro-Script establishes a flow of work presented in Figure 2-2. The application incorporates the following work interactions:

- In the summary of individual work (Personal Discover and Describe Stage) each student must build a small outline or conceptual map, from the notes he obtained during his search for information. This outline is shared at a Virtual Work Table, which is visible to all the members of the group.

- In the summary of group work (Group Build Stage) the students must build an outline or conceptual map where the notes from every member of the group are articulated to show all the information they found and its connections. This outline is built at the Virtual Work Table, where each member was initially working by himself.

- The final hand-out is built using the group summary outline, and it is a written report that one of the members of the group types up, with the help of his teammates.
Table 2-2 shows an application of each step of the CSPM in a specific sequence of activities, broken down according to the two roles the model considers: teacher and student.

Table 2-2: Micro Script for CollSearch

<table>
<thead>
<tr>
<th>Stage</th>
<th>Activity</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Motivation and Domain Definition

<table>
<thead>
<tr>
<th>Teacher</th>
<th>The teacher introduces the topic of the investigation, explaining its general objectives, reach, and focus. In the computer system, he defines the parameters of the activity and uploads the class list, in order to randomly form groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>The students interact with the teacher during the introduction of the investigation topic, just as they would during a normal class. In the computer system, each student registers and logs in, waiting to be randomly assigned to a group.</td>
</tr>
</tbody>
</table>

### Search Term Selection

<table>
<thead>
<tr>
<th>Teacher</th>
<th>The teacher asks the students to suggest search terms that pertain to the topic. He receives the students’ contributions in the computer system, adds more if he feels it is necessary, selects the terms that are to be used during the activity, and sends them to each group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>The students must suggest search terms that they believe will cover the domain and focus described in the parameters of the activity. Suggestions are sent to the teacher anonymously (Figure 2-3 a, Left). Once the terms have been filtered by the teacher, each student must select the required number of terms; in order to do this, they must work as a group and coordinate their selections (Figure 2-3 a, Below).</td>
</tr>
</tbody>
</table>

### Personal Search

<table>
<thead>
<tr>
<th>Teacher</th>
<th>The teacher monitors each group’s progress using his computer interface. When he detects the need, or a group calls him, he can physically approach them and provide help or guidance.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Search topic, which is made explicit in the system through general instructions. Minimum number of search terms each student must contribute. Number of search terms assigned to each student. Minimum number of bookmarks each student</td>
</tr>
<tr>
<td>Personal Build</td>
<td>Student</td>
</tr>
<tr>
<td>----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Personal Discover and Describe</td>
<td>Teacher</td>
</tr>
<tr>
<td></td>
<td>Student</td>
</tr>
<tr>
<td>Group Build</td>
<td>Teacher</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>Student</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group Discover and Describe</th>
<th>Teacher</th>
<th>The teacher monitors each group’s progress using his computer interface. When he detects the need, or a group calls him, he can physically approach them and provide help or guidance.</th>
<th>Length of the final essay.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student</td>
<td>The writing student, who is randomly selected, begins to edit the final document (Figure 2-3 d): he must select the notes from the outline, one by one, send them to the document display and incorporate their contents in a consistent manner; references are added to the paper’s bibliography. When all the notes have been used, the writer notifies his teammates that the document is ready for their evaluation. During the writing process the collaborators who cannot edit become readers; they...</td>
<td>...</td>
</tr>
</tbody>
</table>

\(^1\) This vote considers majority-choice mechanisms, and is mediated by the interface, so when the majority of the group rejects a note, it is eliminated.
constantly check their teammate’s work and help him, mediating through different communication mechanisms (directly or through the group chat). When the document is under evaluation, readers must vote on whether they agree with the result or not. When all the readers agree, the stage and the activity are completed.

In order to keep the tool flexible and adaptable, some stages consider parameters that the teacher must adjust before beginning the activity, so its duration can be adapted and the possible reach of the investigation can be controlled (indicated in Table 2-2). The parameters that determine the minimum number of bookmarks and notes for each student in the individual stages are aimed at making sure that all students collaborate, ensuring a proper division of the work. At the same time, the parameters that determine a minimum and maximum number of group notes aim to control the length of the final paper.

For the proposed Micro-Script, the following are the rules regarding passing from one stage to the other:

- In order to move on to the Personal Search stage, all the members of the group must have selected their search terms. If one team member finishes early, he must wait for the rest to begin his investigation.
- In order to move on to the Group Discover and Describe stage, where the final document is created, students must comply with the minimum and maximum number of web references and notes, both individually and as a group.
- In order for the final document to be finished it must incorporate all the notes that were on the group’s table when they moved on to the Group Discover and Describe stage.
• The final document will only be ready to be checked by the teacher once it has been approved by all the members of the group. The editor of the document must make the necessary modifications, until the entire group agrees on the end result.

### 2.2.2 Communication and Interaction Model

In the empirical evaluation we carried out when presenting the CSPM (Verdugo et al., Submitted for publication) we showed that the collaboration criteria that are connected to communication within a group (Awareness, Coordination and Communication) worsen when the CSPM is used without computational tools that facilitate communication. This is because, in order to maintain awareness regarding their teammates’ work, students must be constantly interrupted in their own work; this makes it necessary to implement technological support for the CSPM that provides transparent communication mechanisms among the members of the group, i.e. mechanisms that don’t interrupt the flow of the students’ work. For the computational tool CollSearch we determined the communication needs that the system had to fulfill in each stage of the CSPM (Table 2-3). The main communication solution was providing the software with a written message chat that is always visible, so the students can communicate at all times, without interrupting the flow of others’ work (Figure 2-3 e). For the individual work stages, we determined the need to create an interface that allowed access to a summary of everyone’s work that could be consulted at any time, by any member of the group. For the group stages we created a Virtual Work Table, where each student contributed his notes and references.
Table 2-3: CollSearch Communication Needs

<table>
<thead>
<tr>
<th>Stage</th>
<th>Communication needs</th>
<th>Technological support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation and Domain Definition</td>
<td>None</td>
<td>*None</td>
</tr>
<tr>
<td>Search Terms Selection</td>
<td>Coordination to select the search terms that will be assigned to each student</td>
<td>*Group chat, which is always visible</td>
</tr>
<tr>
<td>Personal Search</td>
<td>Awareness regarding the bookmarks created by other members of the group, the type of information they have gathered and how advanced their work is</td>
<td>*Group chat, which is always visible *“My Teammates” tab, with a summary of the work carried out by others</td>
</tr>
<tr>
<td>Personal Build</td>
<td>Awareness regarding the number of notes created by other members of the team, as well as their content</td>
<td>*Group chat, which is always visible *“My Teammates” tab, with a summary of the work carried out by others *Shared Virtual Work Table</td>
</tr>
<tr>
<td>Personal Discover and Describe</td>
<td>Awareness regarding how advanced other members of the group are in building personal summary outlines</td>
<td>*Group chat, which is always visible *“My Teammates” tab, with a summary of the work carried out by others *Shared Virtual Work Table</td>
</tr>
<tr>
<td>Group Build</td>
<td>Shared view of the outline or idea map that gathers the group’s ideas</td>
<td>*Group chat, which is always visible *“My Teammates” tab, with a summary of the work carried out by others</td>
</tr>
<tr>
<td>Group Discover and Describe</td>
<td>*Shared Virtual Work Table</td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------------------</td>
<td></td>
</tr>
<tr>
<td>While one student writes the essay, the rest must be able to view what he is writing, offer feedback, give additional information, etc.</td>
<td>*Group chat, which is always visible *Shared Virtual Work Table *Interface that allows students to view the Final Document</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2-3 shows a diagram where the flow of the student’s work is integrated into CollSearch’s main interfaces.
2.3 Empirical Evaluation

The empirical evaluation carried out with the CollSearch tool intended to study the effect that a computational tool based on the CSPM has on the students’ final
performance. We have already shown that the CSPM improves collaboration within work groups, compared to having the group work freely, without following any script (Verdugo et al., Submitted for publication). The goal of the following experiments is to compare the results obtained from manually following the CSPM, compared to the computational implementation of the CSPM through CollSearch.

2.3.1 Methodology

We worked with 36 students from the eleventh grade of a private school in Santiago, Chile, where students belong to a high socio-economic level. We worked with the subject of history, and the goal of the activity was for the students to form groups of three and write an essay about “The characteristics of urban and rural systems”.

The students were randomly divided into 12 groups of three. We carried out three experiences, each 90 minutes long, with four groups participating in each experience:

- Experience 1 - CSPM without specialized technological tools that support a Macro-Script: We carried out an experience where the students followed the CSPM with a Micro-Script similar to the one proposed in section 2, but without considering the use of technological tools that were specially designed for the activity. Students used a web browser, a search engine, a chat tool and a massively used text processor.
- Experience 2 - CSPM in CollSearch: We carried out an experience where the students used CollSearch for the first time, for the proposed investigation.
- Experience 3 - CSPM in CollSearch with Training: We carried out an experience where CollSearch was presented to the students with a preliminary activity in a different subject than the one being evaluated, so that this first exposure would
serve as training regarding the tool. The following week, we carried out an experience similar to the previous two, so we could compare.

The study centered on evaluating each experience according to three criteria: Usability, Collaboration, and Results of the Investigation.

### 2.3.2 Usability Evaluation

CollSearch’s usability evaluation was carried out considering four criteria (Nielsen, 1994):

- **Easy to Learn**: Based on how easy it was for the student to learn the methodology determined by the proposed Micro-Script, whether it be manually followed as a set of instructions—as in the first experience—or using CollSearch—as in the last two experiences—. In order to measure ease, we developed a survey that the students answered at the end of the activity, using a five level Likert Scale.

- **Efficient to Use**: The goal of implementing collaborative search activities within collaborative learning contexts is for students to learn about a certain subject. We decided to measure the model’s efficiency according to the increase in knowledge that the students show after completing the activity. With this in mind, we designed and validated a pre and post-test, and measured the improved or diminished results we could observe when comparing both tests.

- **Subjectively Pleasing**: To measure the satisfaction that the students felt when working with each methodology, we designed a survey where the students answered using a five level Likert Scale.

- **Few Errors**: This criterion refers to what the tool offers in terms of handling errors that may occur during its use; in other words, this refers to the
application’s capacity for resilience, allowing the user to experience fluid use.

Table 2-4 shows the results we obtained. The Easy To Learn and Subjectively Pleasing criteria show the average results in the five level Likert Scale questions where (1) is an unfavorable result and (5) is a favorable result; the Efficient To Use criterion is presented according to the percentage increase in results between the pre and post-test; finally, the Few Errors criterion is shown as the average number of problems identified by the students, out of a total of five options.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>CSPM without applying software</th>
<th>CSPM in CollSearch</th>
<th>CSPM in CollSearch + training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg.</td>
<td>S</td>
<td>Avg.</td>
</tr>
<tr>
<td>Easy to Learn</td>
<td>4,04</td>
<td>0,37</td>
<td>3,42</td>
</tr>
<tr>
<td>Efficient To Use</td>
<td>5%</td>
<td>0,16</td>
<td>7%</td>
</tr>
<tr>
<td>Subjectively Pleasing</td>
<td>3,54</td>
<td>0,46</td>
<td>4,04</td>
</tr>
<tr>
<td>Few Errors</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

2.3.3 Collaboration Evaluation

We considered the following criteria, regarding collaboration: Common Goal, Positive Interdependence, Coordination and Communication, Individual Accountability,
Awareness and Division of Labor (Szewkis et al., 2011; Verdugo et al., Submitted for publication). The details of the evaluation of each criterion can be found in Table 2-5 (Verdugo et al., Submitted for publication), along with the results for each criterion.

Table 2-5: Collaboration Evaluation Methodology

<table>
<thead>
<tr>
<th>Criterion</th>
<th>CSPM without applying software</th>
<th>CSPM in CollSearch</th>
<th>CSPM in CollSearch + training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg.</td>
<td>S</td>
<td>Avg.</td>
</tr>
<tr>
<td><strong>Common Goal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of goal alignment for the work of each member of the group. Evaluation: Essay questions, valued by the observer in percentage of group alignment.</td>
<td>100%</td>
<td>0,00</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Positive Interdependence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To what point do students consider their teammates as essential to reaching their goal. Evaluation: Opinion questions on a five level Likert scale.</td>
<td>4,33</td>
<td>0,71</td>
<td>3,67</td>
</tr>
<tr>
<td><strong>Coordination And Communication</strong></td>
<td>4.17</td>
<td>0.44</td>
<td>3.67</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Level of coordination within the group.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evaluation:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opinion questions on a five level Likert scale.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Individual Accountability</strong></th>
<th>3.72</th>
<th>0.38</th>
<th>3.72</th>
<th>0.25</th>
<th>4.39</th>
<th>0.35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative contribution that the student thinks he is making with his personal work, in order to reach the common goal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evaluation:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opinion questions on a five level Likert scale.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Awareness</strong></th>
<th>3.61</th>
<th>0.51</th>
<th>3.94</th>
<th>0.35</th>
<th>4.61</th>
<th>0.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of consciousness the student has regarding what his teammates are doing.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evaluation:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opinion questions on a five level Likert scale.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Division of Labor</strong></th>
<th>4.72</th>
<th>0.25</th>
<th>3.72</th>
<th>0.67</th>
<th>4.00</th>
<th>0.33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the student think that the distribution of the workload was fair and equitable?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Evaluation:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opinion questions on a five level Likert scale.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3.4 Evaluation of Investigation Results

The end result of the collaborative search activity was a written paper that reflected the results obtained by the group. We had an expert evaluate each essay on a scale of (1) to (4), considering the depth of the ideas the students presented, how completely they covered the subject, and the composition skills they exhibited. The results of this evaluation can be seen in Table 2-6.

Table 2-6: Summary of the results of the activity’s essays

<table>
<thead>
<tr>
<th></th>
<th>CSPM without applying software</th>
<th>CSPM in CollSearch</th>
<th>CSPM in CollSearch + training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg.</td>
<td>S</td>
<td>Avg.</td>
</tr>
<tr>
<td>Essay grades</td>
<td>3,33</td>
<td>0,58</td>
<td>1,86</td>
</tr>
</tbody>
</table>

2.3.5 Analysis of Results

The first thing that jumps to our attention in the empirical evaluation through the three cited criteria is the fact that the result obtained in Experience 1 (CSPM Without Applying Software) worsens in Experience 2 (CSPM in CollSearch) and improves in Experience 3 (CSPM in CollSearch + Training). This shows that developing a specialized tool for the elaboration of collaborative search activities in collaborative learning environments leads to an improvement of results; however, in order to see this improvement, the tool’s learning curve must be surpassed. This could be due to the fact
that the CSPM and the Micro-Script that implements it are a set of instructions that are difficult for the student to appropriate upon first encounter. Once students are familiar with the dynamics of the activity, results improve. This suggests that training is the key to the success of the activity, as familiarization with the technological tool makes interaction with it more transparent. This problem did not arise in Experience 1 –CSPM without specialized technological tools– because we used mass computational tools that the students were already familiar with, and had used before.

The evaluation of the usability criteria shows better results on all criteria for Experience 3 –CSPM in CollSearch + Training– where students first underwent training. One especially interesting result is the evaluation of the Subjectively Pleasing criterion, where the students value the CollSearch tool positively in both experiences. This could be because of the innovative characteristics of the work dynamic, which was reinforced by the comments that the evaluators received from the students at the end of the activity.

The evaluation of the collaboration criteria once again shows that superior results are obtained when using the CollSearch tool with training. Two of the evaluated criteria – Common Goal and Division of Labor– present worse results than in the experience where we manually followed a Micro-Script based on the CSPM. This can be explained with the implementation of the last stage of the CSPM in the CollSearch tool. In the Group Discover and Describe stage, the CollSearch tool randomly chooses a student who will be the designated ‘writing student’, while the other two students will be ‘collaborating students’. Their job will be to read and contribute ideas through the Virtual Group Table, but they will never be able to actually write the essay. This problem, which originates in a technical limitation of the software, presents two negative effects when evaluating collaboration within the group. First, only one student writes the essay, and even though he has help from his teammates, this leaves students with the feeling that the Division of Labor was not equitable. This did not happen when the CSPM was followed manually, without technological support, because the students took
turns writing the essay. Second, the designation of a ‘writing student’ leaves the ‘collaborating students’ with the feeling that the paper doesn’t fully comply with the characteristics that they visualized for the final document, and this worsens the goal alignment evaluation that is carried out under the Common Goal criterion.

The evaluation of the final investigation results –the essays that the groups hand in– is consistent with the general tendency of improving results in Experience 3 (CSPM in CollSearch + Training) and worsening results in Experience 2 (CSPM in CollSearch). It is interesting to note that, even though the evaluation of knowledge –which is measured through the Efficient to Use criterion (Table 2-4) – is better in Experience 2 than in Experience 1 (which means that when students use CollSearch they show better learning results, even if they have no previous training), the evaluation of the final paper is worse in Experience 2. This can be explained because the first encounter with the CollSearch tool implies an initial learning cost that translates into reduced work speed, and lower comprehension of the pedagogical activity and the subject that is being investigated. This means that the time available for the final stage of the CSPM –writing the final essay– in the case of Experience 2 was shorter than in Experiences 1 and 3, and this logically shows in the quality of the work.

2.4 Conclusions and Future Work

In our previous study we presented the need to create computational tools that foster collaborative search processes in the context of a collaborative learning environment (Verdugo et al, Submitted for publication). Our first approximation towards modeling collaborative search processes with multiple users is the model with three levels of depth that conceptualizes the collaborative search process through an articulation of Kuhlthau’s ISP (Kuhlthau, 2010), along with the Collaborative Search Procedural Model as a Macro-Script and its implementation through various Micro-Scripts.
The specialized CollSearch software implements the CSPM through the Micro-Script presented in Section 2.2, and shows empirical improvement in the results of students who face a collaborative search process, as long as they have a previous training session. One possibility for future work is the study of the effect that different applications of the CSPM through different Micro-Scripts could have on the final results of these activities, as well as searching for strategies that make it possible to avoid the initial training stage. In the specific case of the Micro-Script that is followed with the CollSearch tool, there is the possibility of implementing a new version of the tool, which offers a more natural distribution of the workload when it comes to writing the final paper. This could improve the feelings students have towards the Division of Labor and Common Goals criteria.

The empirical evaluation we carried out reflects the importance of training regarding the final results obtained by the students. A possibility for future work is a more extensive study that follows students through more than two activities, guided by CollSearch. A long reach study could show the effect that collaborative work dynamics, such as those proposed by the CSPM, could have on students’ general performance regarding meeting curricular goals, compared to working without the tool.

The student’s positive evaluation regarding the Subjectively Pleasing criterion in the usability evaluation, as well as the comments received by the evaluators at the end of the activities that were carried out using CollSearch show the positive reception that young people have of new technologies that adapt better to their work habits. As shown in past investigations (Verdugo et al, Submitted for publication; Morris & Horvitz, 2007) collaboration in search tasks is a daily reality, and the search model where a single user interacts with an interface must be reconsidered. New tools that foster collaborative work dynamics in searching for information must be developed in order to take advantage of what social interaction contributes to the search process.
REFERENCES


APPENDIX A: PAPER RECEPTION LETTER

Date: 01 Jul 2011
To: "Renato Verdugo" rverdugo@ing.puc.cl
From: "The CSCW Journal" jubilin.hilaria@springer.com
Subject: Submission Confirmation

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