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Complementary User-Centered Methodologies for Information Seeking and Use: System's Design in the Biological Information Browsing Environment (BIBE)

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Abstract

Complementary socially grounded user-centered methodologies are being used to design new information systems to support *biodiversity informatics*. Each of the methods—interviews, focus groups, field observations, immersion and lab testing—has its own strengths and weaknesses. Methods vary in their ability to reveal the automatic processes of experts (that need to be learned by novices), data richness, and their ability to help interpret complex information needs and processes. When applied in concert, the methods provide a much clearer picture of the use of information while performing a real life information-mediated task. This picture will be used to help inform the design of a new information system, Biological Information Browsing Environment (BIBE). The groups being studied are high school students, teachers and volunteer adult groups performing biodiversity surveys. In this task the people must identify and record information about many species of flora and fauna. Most of the information tools they use for training and during the survey are designed to facilitate the difficult species identification task.

Socially Grounded User-centered Methodologies

It is obvious that going digital has as much to do with social transformation as technological conversion (Levy and Marshall, 1995). For any aspect of technology use is very much 'embedded' in real social settings and contexts (Nardi & O'Day, 1999). Thus, the design of technological systems for biological information and online visual browsing tools for biological information need to have the following characteristics:

- **They should be socially grounded and participative**: This is dependent on the fact that the success of a socio-technological system is based on the adoption by its users (Fischer, 1992).
- **They should be shaped by users' needs, expectations, and situations of use:** This is because these factors are significant determinants of the usability phenomena (Suchman, 1987).
- **They should accommodate social practices of users associated with system use:** The documentation of social practices should inform system design for successful implementation (Bowker, et al., 1997).

Multiple socially grounded, user-centered methodologies are being employed in the Biological Information Browsing Environment (BIBE). These complementary methods often reveal detailed conditions of information seeking behaviors of users to achieve specific goals. No one approach or user group can provide all of the personal, social and technical information needed to understand the user needs but the combination of approaches provide new insight into the use of information and the information needs of the users in this context. The application of multiple user-centered techniques produces a synergistic effect. This is the synergistic user-methods thesis. The insights from one method not only fill gaps in other methods but directs and amplifies the application and results of other research methods. These methods identify aspects about user dynamics, social roles, barriers faced, expectations of participation, role of prior training, use of resources, and impact of computers. No one method was able to provide all this information about the participants.

Each methodology has strengths and weaknesses for eliciting different kinds of information. For example, focus groups are considered particularly suitable for obtaining several perspectives about the same topic, though problems arise using this socially grounded research strategy when the researcher has to identify the individual view from the group view (Gibbs, 1997). In order to compensate for the lack of voicing in individual perceptions on some topics in the focus groups, a number of formal and informal interviews were conducted to hear concerns of various stakeholders. The following sections present contextual use and descriptions of some of the user-centered techniques that were employed in the BIBE Project.

The Context

In order to understand the use of information it is important to understand the context of use; the task, the goals and skills of the participants. In this case we are studying people conducting biodiversity surveys. The primary goal of the people conducting the survey is to define a study area and then to document the organisms that live in that area. Students and adult volunteers need to perform many tasks as part of EcoWatch but one of the most challenging tasks is species identification. EcoWatch is a program run through the Illinois Natural History Survey (INHS). In this program, citizen volunteers, who are often not scientists, gather information about the biodiversity and health of natural areas. Participants need to be able to identify hundreds of plant and insect species. In this project, we are studying how the participants learn to identify species and when they fail. The objective of the BIBE project is to understand the information use and information needs of several groups of participants (Heidorn, 2001). The study of information use in this context is called *biodiversity informatics*. Biodiversity informatics is a broad area of research and application. The mission of biodiversity informatics is to provide information-related support to the process of identifying and quantifying biological diversity. The process of information gathering and analysis, as well as the information itself is used to support research, education and policy development. This information is critical to understanding ecosystems and the impact of human and natural phenomenon upon those systems.

Many scientists believe that the earth is facing the loss of large numbers of species (Ehrlich and Wilson, 1991). For example, during the next fifty years up to two-thirds of plant and animal species, mostly in the tropics, may be lost (Raven, 1999). This extinction would have an impact on evolution that would last for many centuries (Myers & Knoll, 2001). This information is essential for gauging the planet's health yet little is known about ecology and biodiversity compared to user biological disciplines. "... ecology and conservation biology are still disadvantaged. Their growth is hampered by a seldom-acknowledged deficiency: out of ignorance of the world's biodiversity, particularly at the level of individual species, where knowledge is fundamental to all other studies of diversity and hence of the whole living environment (Wilson, 2000)."

The Studies Approach

We are closely studying a small sample of people involved in biodiversity surveys. To date this has included interviews with three teachers and three professional botanists. There have been three ForestWatch field observation trips videotaping thirteen students and two teachers. There have been two focus groups including a total of seven high school students. Two of the research team members were trained in ForestWatch and one in PrairieWatch. Both can be considered informants in the process. This represents dozens of hours of audio, video and field notes and hundreds of pages of transcripts but still is a small sample of the participants in the program. 340 Illinois high school teachers from over 300 different schools have been trained in at least one ecosystem monitoring program (RiverWatch, ForestWatch, PrairieWatch, WetlandWatch, and UrbanWatch) through the PLAN-IT EARTH partnership. As numbers are cumulative, we could conservatively estimate the EcoWatch program has reached between 15,000 and 20,000 students in classes taught by these teachers. In addition, hundreds of adult volunteers monitor hundreds of forest and river sites.

Interviews, Botanists: There were two types of interviews conducted in this project. The lead questions for one set of interviews were designed for professional botanists. Six interviews were conducted at the Missouri Botanical Garden and the INHS in the summer of 2000. There was a fixed set of questions about sources of information for identification. They were ordered from the open-ended to specific questions. These included the design of identification keys, the selection of characteristics and character values for identification and the design of flora. Each interview lasted about two hours. Field notes were kept on the interviews. These interviews revealed how the experts who author paper-based keys intend for them to be used as well as some of their known shortcomings. The results of these interviews were used to design prototypes of identification systems that were used in the focus groups and interviews with teachers in the fall of 2000 and spring of 2001. The strength of these interviews was that they provided design input from people who have many years of experience with these information tools. One weakness is that the interviews provide only second-hand information about the end-users of the tools (Coolican, 1990; Nielson, 1993). Another weakness is that experts after years of effort have become so highly trained that many of the difficult processes involved in identification may have become automatic (Newell et al., 1990). This can make it difficult for experts to predict what will be difficult for a novice. This problem was reduced in our study since some of our interviewees were also teachers and are frequently reminded of these difficulties. One interesting observation about the use of paper keys was that they require several minutes per species for an accurate identification. As was observed several months later during field observations, this proved to be a barrier to the use of the keys.

Interviews, Teachers: The second set of interviews was with high school teachers immediately after they had completed biodiversity surveys with their students. These interviews were formal and directed by a fixed set of questions that paralleled the questions used in the focus groups with students discussed in detail below. These interviews were recorded and transcribed. These interviews had the strength of providing insight into the unstated goals of project in the eyes of the teachers. As might be expected, the goal was to teach students about ecology but more generally about the scientific method. Many additional classroom activities are tied to the EcoWatch fieldwork. Teachers used the PLAN-IT curriculum to insure that classroom activities met the Illinois State Teaching Standards (Lisowski, 1997). PLAN-IT was developed concurrently with ForestWatch procedures. Through the curriculum, students learn concepts such as sampling technique, biomes and biodiversity. Some of these goals were apparent in classroom observations, some were not.

Another strength of the interview technique is that it allows the researchers to discover why the classes were organized the way they were. The "why" of activities is not apparent from field observation alone. Teachers are conscientious about the quality of the data being submitted to the IDNR. Some decide not to submit the data but to keep the survey as a purely academic exercise. Teachers were also concerned about the time constraints imposed by the classroom setting. After accounting for travel time, students only have 40 minutes to conduct the tree identification portion of a survey. Teachers compensate for this through classroom training, practice field trips to non-official ForestWatch sites, and by assigning different survey activities such as site boundary layout to different classroom sessions. In large classes teachers can assign one of the three 50 meter transects to a different group of students. The weakness of these interviews is that the results were mediated by the teacher's goals and desired outcomes. While the teachers were candid and honest in the interviews, because of the necessary time constraints of a one-time interview, the reports were oversimplified representations of reality of the work being conducted by the students. This could be addressed through interviews with multiple teachers and through multiple interviews with the same teacher during different phases of the classroom activities.

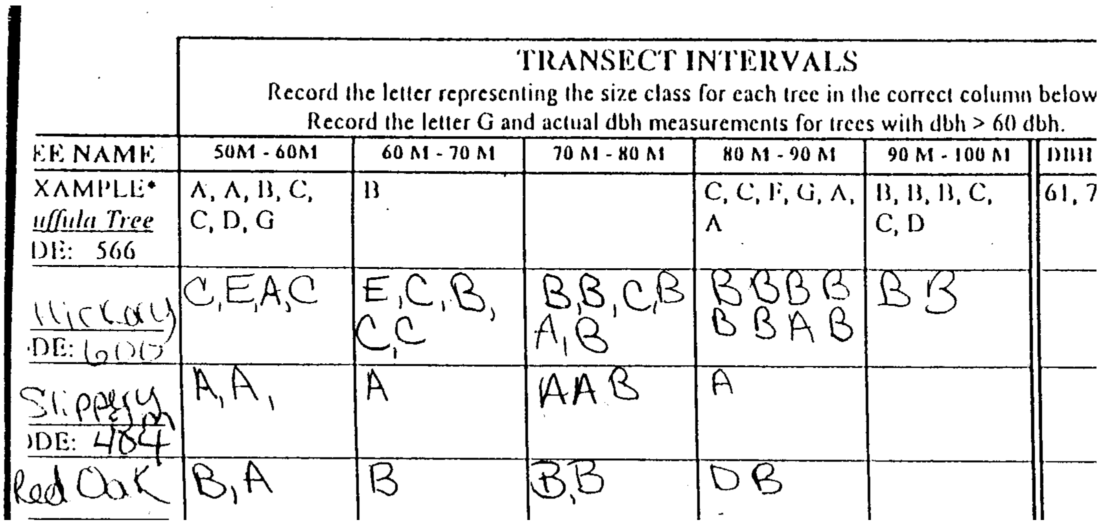
Immersion: One method to gain a better understanding of user needs is to become a user (Beyer & Holtzblatt, 1995). In this approach, system developers endeavor to have the same training, experience, and perform the same task as the people who will use the system. In immersion, rather than simply observing others performing the survey tasks, the designers perform the tasks themselves. ForestWatch volunteers are given a day of training on the survey procedures and species identification. After classroom work the volunteers go to the fields to conduct a practice survey. Bryan Heidorn, the Principal Investigator on the project, received ForestWatch training and became a certified ForestWatch volunteer in the spring of 2000. Likewise, Mary Lokhaiser, a doctoral student working on the project, received Forest Watch and PrairieWatch training in the summer of 2000. Observing volunteers making mistakes in species identification and using information aids is very different from needing to distinguish between an American Elm from a Slippery Elm yourself. These experiences serve as a first-hand source of understanding of the information needs of participants, including not only plant and insect identification information but also good sources of treatments for poison ivy, insect bites and sunburn.

A weakness of this approach is that it is often impossible to apply in real life situations because of costs, time or physical limitations. A white middle-class male designer can not become a poor, minority mother with an information need. (Thus, it is wise to invite users to participate in the design.) Fortunately, in the case of ForestWatch, it is relatively easy to become a volunteer. Another potential weakness of immersion is automaticity. As processes become automatic, as you become good at a task, you no longer recognize what was difficult in the beginning. Since training for all volunteers is brief, this did not prove to be a real problem.

Field Observation: Field observation trips in the fall of 2000 and spring of 2001 provide examples of the techniques used in the study and the information we can gain by observing information use in context. The goal of the observations is to determine where the participants make mistakes, why the mistakes are made and find solutions. The field observations also provide information on volunteer interactions. The participants' discussion among themselves and their actions tell us what they consider to be important and what characteristics of the species they focus on.

The main goal of the participants was to fill out a data form that is used by the Illinois Department of Natural Resources. An example of part of one of the forms is included in Figure 1. The information they must gather includes the identification and size of all trees in each 10-meter section of three 50-meter survey areas. In the fall 2000 field observation, two researchers video-taped five Illinois high school students during a fall ForestWatch survey on one 50-meter interval while a third observer took field notes. The field notes included time stamps, and a sequential list of the species assigned to trees along with the speaker. The same team then recorded the behavior of two professionals surveying the same site. This observation served as a standard against which the volunteer participant judgements could be based. Two cameras are necessary because the participants, while working together, can be over 10 feet apart. Even with the two cameras it was sometimes difficult to determine which individual was speaking and how decisions were being made. The team was unable to match, tree for tree, the identification of the trees. To complete the analysis, the research team had to return to the forest with another tree identification expert and create a map of the location of each tree and its species name. It was only then that we were able to complete analyses of the videotapes.

In the fall of 2001, we changed the nature of the field notes and as a consequence were able to reduce the number of cameras to two. The new field notes take the form of a rough map. While the volunteers work, the researcher plots the location of each tree along with the time and its volunteer assigned identification and size. During data analysis we were able to much more easily follow the video.



TRANSECT INTERVALS

Record the letter representing the size class for each tree in the correct column below

Record the letter G and actual dbh measurements for trees with dbh > 60 dbh.

EE NAME	50M - 60M	60 M - 70 M	70 M - 80 M	80 M - 90 M	90 M - 100 M	DBH
XAMPLE* uffula Tree DE: 566	A, A, B, C, C, D, G	B		C, C, F, G, A, A	B, B, B, C, C, D	61, 7
Hickory DE: 600	C,E,A,C	E,C,B, C,C	B,B,C,B A,B	BBBB BBAB	BB	
Slippery DE: 484	A,A,	A	AAB	A		
Red Oak	B,A	B	B,B	DB		

Figure 1: ForestWatch Data Input Form

The information resources used in the field include: laminated color pages with plant images and descriptions as in Figure 2; web descriptions of the tree which volunteers had printed out as in Figure 3. These are provided by the IDNR. Volunteers also used field guides such as the Forest Trees of Illinois (Mohlenbrock, 1991).

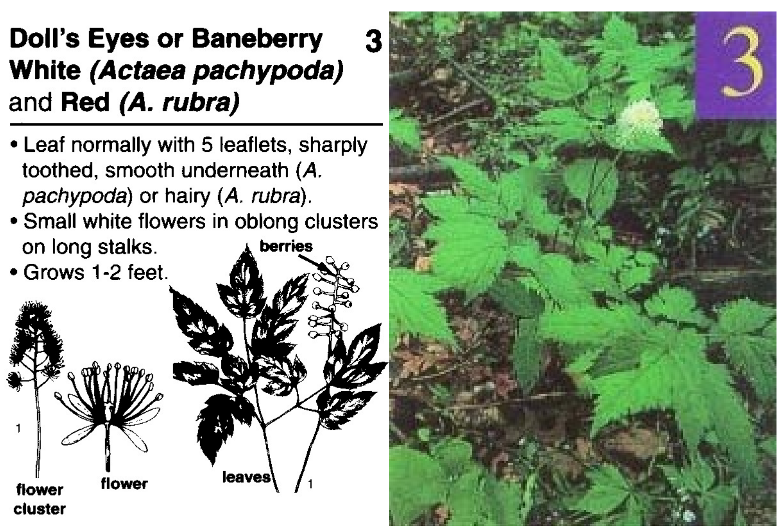


Figure 2: Laminated Sheet Plant Image

Figure 3: Web Resource

The students and teacher identified a majority of the trees correctly; however, researchers were interested in the process of identifying trees incorrectly in order to devise a system to improve EcoWatch data gathering accuracy. The field videos and maps allowed us to identify several error types that might be easily corrected. Consistent with the synergistic methods thesis, interviews and other techniques would not have revealed these errors but did suggest the solution.

The survey took the students 35 minutes to complete. In that time they identified 55 trees at a surprising rate of one and a half trees a minute. This conflicted with the professional estimates of how long it should take from the interviews but the teaches had trained the students in fast identification prior to entering the field. Only 42 trees were considered to be in the survey area. The remainder were outside of the area and should not have been counted. The identity of one of these could not be confirmed. There was one tree that may have been missed by the observers but the difference was mostly attributable to trees on the edges of the survey area. This was an unexpected discrepancy. This may indicate a need to change the techniques for laying out survey areas or changes in instructions to the volunteers. All further discussion in this paper is limited to the 41 trees that were identified by both the volunteers and the professionals. The professionals and the volunteers agreed on 33 of the 41 trees (80%). The following table is a breakdown of the differences between professional IDs and volunteer IDs.

Table 1: Misidentifications

Professionals	Volunteers
American Elm (3 instances of misidentification)	Slippery Elm (3 instances)
Catalpa	Sassafras
Sassafras	Ash
Dogwood	Sour Gum
White ash	Hickory
Flowering Dogwood	Alternate Dogwood

Of the eight errors, three were because of confusion between two elm species. It is relatively difficult to tell the difference between the American Elm and the Slippery elm since the main differences are that the upper surface of slippery elm leaves are rougher than the American elm. From the videos, we know that the professionals always felt the leaves or broke off a small sample of bark to see if it had the red line characteristic of the American Elm. The volunteers never did this.

Some important design consequences from the field observations are that the student volunteers rarely consulted the information resources that they had on hand. Printouts of web-based tree IDs in Figure 3 were used twice. They identified almost all trees from memory. At least for trees, where it is possible to memorize species, it might be better to design systems that aid learning rather than systems to be used in the field. Students were impatient with the amount of time required to use keys and field guides. Any tool used in this context would need to be able to identify species in seconds rather than minutes. Another observation is that students follow specific social roles that are in part dictated by the mechanics of the situation. One person records data, another measures tree width, one reads coding information and one or two individuals are recognized as "experts" or "authorities" in identification. These mechanics and roles are important to consider in the new design.

The strength of field observations is that they provided an unfiltered view of the information task. Unlike the other methods used in this study, the field observations were not interpreted through the perception of the participants. Most user actions and all conversation were captured. The difficulty with the approach is the volume of the data. It is difficult to associate, one-for-one the opinions of the volunteers and those of the experts. The students are, however, incorrect part of the time. The focus groups conducted after the survey helped uncover some of the reasons for these errors. One reason for these failures may be overconfidence in their own knowledge and the knowledge of the "authorities."

Focus groups: Focus groups allowed social dynamics to feed ideas between participants. In order that issues be fresh in the minds of the participants, focus groups were conducted immediately following biodiversity surveys. Powell & Single (1996) define a focus group as “a group of individuals selected and assembled by researchers to discuss and comment on, from personal experience, the topic that is the subject of the research” (pp. 499). Characteristic features of focus groups that proved significant in their use in the BIBE project included organized discussion (Kitzinger 1994), collective activity (Powell et al 1996), social events (Goss & Leinbach 1996) and interaction (Kitzinger 1995). Focus groups in the BIBE project were formal discussions organized around the biodiversity surveys in which the students had participated and interacted with each other.

Focus groups were conducted with students during Fall 2000 and Spring 2001 monitoring sessions. Additional focus groups will be conducted over the next two years. The focus groups are composed of two parts. The first part includes a series of questions about the classroom and ForestWatch survey activities. Significant issues addressed in the focus groups were: visions and expectations of participants; prior preparation and training activities; past experiences and procedures followed; distribution of roles and social dynamics; use of resources; barriers and what worked well in different situations; suggestions for improvements; and use of computers. The second part begins with a demonstration of an interactive key program, IntKey (Lawrence et al., 1999). The participants are then invited to use the program and are asked about their general impressions. This is followed by a series of specific questions about each of the major features of the program. Finally, having been primed as to some computer-based possibilities, the volunteers are asked, "What could be done to improve the survey process?". The focus groups also provided feedback about the use of a number of identification tools such as keys, the EcoWatch training manual, colored pictures provided in the EcoWatch training packet, other books and brochures, online sources, etc. that are employed during the biodiversity surveys conducted in EcoWatch programs. The focus groups also included having participants interact with computer-based keys. Transcriptions of audio recording provided direct quotations, detailed statements, key suggestions, and noteworthy experiences. Additionally, notes taken by researchers helped record the complexities of participants’ experiences.

During the Fall 2000 monitoring survey, researchers conducted a one-hour focus group at a high school. Four female high school students of the twenty-plus students, who had participated in prior field observations, participated in the focus group. Researchers conducted an approximately one-and-half hour focus group during the

Spring 2001 monitoring season at a high school in Central Illinois. Three male high school students participated in the focus group and narrated their experiences in past and present EcoWatch programs. These three students were the only students in the class that that conducted the survey. There was no indication that the gender of volunteers had any impact on the focus groups. The following were some significant findings during these focus group discussions:

- Training before entering the field is essential for the task of plant identification. Students, including those with no prior experience, did learn a great deal about trees in the classroom and around the school before going to the field. One participant stated, "I have learned a tonne from trees cause when I first came in I knew, I didn't know any trees at all and now I mean I know the main ones. You know, if it's a maple or it it's an oak or I don't know you know specific types, but before I'd look at a tree and be like 'Oh, it's pretty. Don't know what it is, but...'"

- Students believed that computers, particularly resources available on the Internet, could play an important role in tree identification. As one of the participants stated, "Well, also you could do it where you could... take that and like hook it up, like have the Internet going, and give you sites to where you can go and ask somebody, maybe like, or it has like helpful hints... or you can just like get on the Internet and like show them the leaves you know with the scanner or just compare."

- We learnt how traditional tree identification guides were not as useful or as trusted as expert opinion, good quality photographs, and leaf collections. As one student stated, "It's easier for me to see it... instead of having someone look it up." Another student spoke of the significance of photographs and images as compared to traditional textual descriptions, "I mean that's the easiest way for me to see a picture, see somebody doing it, not written down."

- From notes made during the focus group discussion, some of the reasons why the students did not use the materials in the field included the following: students' over confidence in their knowledge as applied to plant identification; low motivation factors; the lack of appropriate, easy-to-use keys with color images; and time limitations for the tasks at hand.

- Volunteers quickly arrived at a consensus even when the consensus was wrong. Volunteers with a correct hypothesis for the identification of a species would too quickly yield to other opinions in the group without referring to the available paper resources to verify the identification. One solution might be to restructure both the social dynamics and the forms to help foster debate and verification. For example, at least two individuals might independently identify each tree. Software could point out discrepancies and species characteristics that would resolve the conflict.

From both focus groups conducted during Fall 2000 and Spring 2001 monitoring seasons, there were some important differences noted about the nature of students participating in the biodiversity surveys and the procedures adopted during those times. Briefly presented are two significant differences:

- Three students participated in the biodiversity survey conducted during the field observation in spring 2001. The same three participated in the focus group. Out of the three, two of the students had participated for the past three years in biodiversity surveys at the same sites. On the other hand, during the fall 2000 monitoring season, there were 27 students who participated in this biodiversity survey. Of the five included in the focus group and field observation, none had previously conducted a survey.

- The nature of class settings of students participating in a biodiversity survey has a tremendous impact upon the social and group dynamics expressed in the field, the level of participation of the teacher in the plant identification process, and the demarcation of student roles while conducting the surveys. During Fall 2000 monitoring season, since there were many students on the site, it was practical to divide them into groups of 5-6 students each. The teacher assigned each group to one of the three transect lines. During the Spring 2001 monitoring season, since there were only three students participating, one group completed all the data collection along the three transect lines. The teacher was able to give more focused attention to the tasks being performed. In this situation, the teacher immersed herself in the process of identification and contributed actively in the process. She took the role of an expert or supervisor for the student group. Her decision was equally respected and rarely contradicted by group members. The teacher assigned one of the students, who was participating in the biodiversity survey for the first time, the role of recording. Since the other two students had participated in biodiversity surveys of the same site for the past consequent three years, the teacher had complete faith in their identification skills. In Fall 2000 monitoring season, the teacher was more involved in assigning groups and insuring that the groups completed the tasks at hand, and only occasionally became involved in the details of identification. Consequently, each group had to assign different roles to its members and one of them took on the role of the expert or leader in the task of identification. Based on past experiences, this person's decision was often accepted by other students unequivocally, though there were some occasions where a discussion ensued before this person's decision was finally accepted. The other group members took on roles of recorder, verifier, measurer of plant characteristics, person involved in discussion, person carrying materials, etc. Sometimes the expert/leader and recorder or note-taker was the same person.

Differences in Goals:

There are sometimes conflicts between the goals of the main participants in EcoWatch. For examples, the IDNR scientists are the State legislature are interested in long term trends in the state environment. Consequently, they are not interested in looking at data from a single season alone but need information for five, ten or more years before it is useful. Adult volunteers, teachers, and students however frequently have more immediate goals. These groups are interested in the "their" plot of land or their stretch of river. They are concerned when an invasive species was identified. For example, on finding what they believe to be an invasive garlic mustard (*Alliaria petiolata*), they are tempted to pull it out (although we have not observed them actually doing so in their survey plots). These groups are also much more interested in seeing the fruits of their labors in the short term. All three teachers that were interviewed reported that they would like to see how their data is being used shortly after it is submitted.

Conclusion

Multiple user-centered methodologies are being applied in an ongoing project to design an information system to support biodiversity survey work by adult and high school volunteers. No one approach or user group can provide all of the personal, social and technical information needed to understand the user needs. The combination of approaches provide new insight into the use of information and the information needs of the users in this context.

There are many axes along which the effectiveness of methods for studying information seeking and use can be gauged. There are three main axes that are discussed here. These include controlled vs. automatic processing, interpretation vs. direct perception, data richness vs. interpretability. The user groups in the study varied in terms of the level of controlled vs. automatic processing which therefore impacted the transparency of their responses. When people are initially learning a skill, they must give conscious attention to the task in order to accomplish it. During this phase, people can easily verbalize what they are trying to do since the tasks are frequently verbally mediated. Students, teachers and some adult volunteers fall into this group. This group is also the main group to be served by the new information services planned in this research. Focus groups, interviews and field observation can all reveal information about the information constraints on the task. Immersion of the designers into the information task forces the designers into a mostly controlled mode form of processing. This allows for more direct observation of the difficulties experiences by other novices. Unfortunately, the novice volunteers and the researcher/designers do not always know the "best practices" and sometimes can not successfully accomplish the tasks. Experts such as botanists have the required knowledge but it can be tacit and automatic. Experts may not reveal critical knowledge during interviews unless directly prompted for information. For example, in the field, experts frequently "just know" the identification of tree species. They may say, "That looks-like a sugar maple" without verbalizing what it is that makes it look like a sugar maple. Field observation reveals some of this knowledge. For example, when the experts are identifying elms they peel off pieces of the bark. The action indicates a critical piece of information, that is, “orange and white stripped bark indicates an American Elm.” Additional insight can come from experts through the complementary methods, novice interviews and field observations. Questions and errors from the novices can also be addressed by the experts.

The next major axis is interpreted vs. direct perception. Some methods are good at eliciting information about frequently unspoken goals and motives. Interviews with scientists and teachers provide this sort of information. However this level of interpretation is also potentially subject to reporter bias. The interview can lead to oversimplification or an idealized view of a complex situation. This method is complemented by field observation of novices that can expose these oversimplifications through direct observation. At the same time, the results of professional interviews can form a framework for interpreting the immense amount of data that can be collected in field observations. This dimension is correlated with axis of data richness vs. interpretability.

Field observation can provide a rich source of data for design. In our case it included field notes and maps as well as video recordings. We were able to identify information resources used in the task including field guides, ForestWatch identification keys and reports of prior surveys. The difficulty comes in interpreting the data and deciding how this interpretation should effect design. Focus groups with the novice volunteers after surveys complements this data, helping to determine what is important and what is not, what is difficult and what is easy for novices. Immersive design allows observers to better understand the non-obvious mental and emotional processes of the volunteers. Separate interviews with experts help to fill in missing knowledge of the novices.

Interviews, focus groups, immersion and field observations of different groups of users give complementary perspectives on the information needs of people performing information dependent tasks. Each method can be used to compensate for some of weaknesses of the other methods.

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