Information Behavior of Small Groups: Implications for Design of Digital Libraries

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Abstract. We report findings of a study that investigates the information behavior of online small groups engaged in math problem solving and discuss the implications for designing digital libraries that can support learning of younger students and their broader information practices.

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K.3.1 Computer Uses in Education

General Terms
Design, Human Factors

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1. INTRODUCTION
Digital libraries have the potential to enhance learning by providing resources and connectivity among people [1]. Yet, it is a challenging research problem to design a digital library on a specific subject for younger users (e.g. from elementary to high school) and, particularly, to support their collaboration and learning. Many digital libraries are not explicitly designed to support learning, which is a much more complex practice than simply browsing and searching. Most existing digital libraries are no more than repositories of information objects, organized according to structures that may not be compatible with how young users would organize them. Deeper understanding of how the users of a particular age group look for information for learning purposes are needed in order to design digital libraries to support their information practices, e.g. information needs formulation, information seeking and information use.

The Math Forum (mathforum.org) is an established organization that provides online educational resources for mathematics, including math digital libraries and mentoring services. The *Virtual Math Teams* (VMT) [2] project is designing and deploying a service to bring students together to explore math collaboratively in online environments. Students are invited to work in small groups of 3 or 4, and are given a non-routine math problem to solve. In sessions conducted in VMT, we observe participants actively engaged in various information practices within the group. We believe that analyzing how participants constitute their information problem and how they address it using available resources can provide us with a better understanding of fundamental problems of information behavior. This could inform the design of information resources and digital libraries. In this paper, we look at sample interactions that illustrate the negotiation of information needs, the use of information resources and the co-construction of meaning.

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2. RESEARCH METHOD
We have held over 70 sessions with groups of students logging in from home or school. Some sequences run with the same group for four sessions over two weeks. Our participants range from 6th to 12th grade. In most cases, group participants come from across the country. The interactions are mediated entirely through the virtual environment. We started with experimenting using AIM® and later developed our own *VMT Chat* that has a chat program along with a shared whiteboard. We also tried integrating wiki into the environment as a shared workspace where groups build on each other's ideas. A typical VMT session is about one hour long. Participants work on a math problem collaboratively in small groups. The interactions are recorded and are available for later analysis. Taking the group as the unit of analysis, we have applied an ethnomethodologically-informed approach [3] based on aspects of conversation analysis [4] to analyze information practices of participants. Such micro-level analysis usually focuses on episodes of activities that are of research interest and examines them at great detail from an *interactional perspective*.

3. DATA ANALYSIS AND FINDINGS
Negotiation of information needs. When working on a math problem, participants try to identify what is known and what they still need to know. In excerpt 1 from a VMT session, three participants identified by initials are trying to figure out what the height of a pool is, which is not directly given in the math problem but might be implied from the problem description. AME starts with posing the question, which provides the group what he understands and calls for assessment of the information. It turns out to be an *information problem* that they need to resolve, that is, to produce a shared understanding of what is known and what needs to be known. For AME and HOL, the height didn't seem to be a problematic issue at the beginning: AME thinks the height is 25 whereas HOL thinks it is 2m. For KIM, the heights are given

in the picture. The conflict of their views initiates a negotiation and co-construction of their information needs. Here we see how information needs—like the height—emerge as a product of the social interaction engaged in resolving a problematic issue, or in other words, their shared information problem.

AME	The height of the olympic pool is 25 right?	7:32:31
KIM	rereading	7:32:50
HOL	height is 2m	7:33:33
AME	wha?	7:33:39
KIM	I think we're looking at a side view - so the heights are given in the picture	7:33:44
AME	I disagree	7:34:38
KIM	it says, "They are usually 50 meters by 25 meters, when looking from the top"	7:36:30
HOL	?	7:36:50
KIM	then, "the picture below shows the depths"	7:37:59
AME	yeah but whats the height?	7:38:19
HOL	height from what perspectiv	7:38:58

Excerpt 1: Negotiation of an information problem.

Use of information resources. We have observed that when encountering the need for information, participants in most cases turn to the group for help. The *group* serves as a primary resource for them. This is not surprising because there is locally produced information that may be only available in their local situation and the group understands the context of the information question. Participants ask questions to seek information, offer what they know in response to information inquiry, articulate their understanding, or recall what they have learned in prior experiences. There are observable tactics that participants use to frame their *information questions*, such as offering a candidate answer or calling for participation. In excerpt 2's session, SUP has a question regarding "edge lengths" (of a triangle). The question is directed to the group with a candidate answer provided ("jone of the 3 sides?"), which is taken up by AVR who provides a straightforward answer. In some other cases, we see similar information questions being addressed differently, for example, by providing a link to some resource that may have the answer.

SUP	what does itmeans by edglengths?
SUP	jone of the 3 sides?
AVR	edgelength means length of a side

Excerpt 2: An information-seeking question.

NISH	hope this doesnt sound too stupid, but wuts a summation
137	The sum of all terms from a to b
JAS	http://en.wikipedia.org/wiki/Sigma_notation

Excerpt 3: Different answers to an information question.

Using online resources is also observed as a common practice. Many participants demonstrate they are familiar with using online resources. Students seem to have expectations for online resources to provide them straight answers, such as a formula that solves the problem. But there seems to be a discrepancy between students' perception of what online resources can offer and the reality in which resources fail to satisfy their needs. Analyzing such information search breakdowns helps us understand how young students search for information.

Construction of meaning. In excerpt 4's session, participants are working on finding out the number of possible paths between two points on a grid. NISH proposes that permutations can be used to find out the possibilities, which poses a problem for other participants in understanding how the information could help solve "this". Upon JAS's request, NISH draws a tree diagram on the shared whiteboard to illustrate the idea (which is recorded on the session history that is not shown here). They are engaged in constructing the meaning of "permutation" in their particular problem context.

NISH	well the way i know how to find number of possibilities is through permutations and tree diagrams
JAS	can you show us by drawing on the board?
EUR	i dunno bout the permutation
EUR	how do u use it to solve this
JAS	i dun either

Excerpt 4: Discussing how to use information.

We have observed that when some potentially useful information is brought in, participants may have difficulty applying it locally. They have to do the work of *constructing the meaning of information* and make real information meaningful and useful for themselves. Information here is not a static object bounded in a box but interactionally constructed through social interactions.

4. IMPLICATIONS

The findings from this study have important implications for designing digital libraries for learning. 1) They speak to the need for digital libraries to incorporate spaces and functions to support social interaction, since seeking and using information with other people is a natural and primary practice for many users. A shared work space where people can interact with others and ask questions may help information seeking and sense making. 2) One can go beyond the notion of a digital library as a simple repository with static information. To meet users' needs, a library can support broader information practices, which may be oriented to problem solving, learning or other tasks. 3) Digital libraries can be integrated with learning environments to offer an integration of resources and interactional spaces that can support learning and knowledge building within communities of practice. At VMT, we build up a digital library of the work of those virtual math teams to which all the groups contribute content. It is a shared interactional space where participants collaboratively build knowledge. 4) Analyses of our experiences at VMT shed light on understanding how people construct information problems, pose information questions and use information resources. This is just an initial step in designing digital library facilities to support the information behavior of small groups in a networked world.

5. ACKNOWLEDGMENTS

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