
Just Curious: Children's Use of Digital Reference for Unimposed Queries and Its Importance in Informal Education

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ABSTRACT

This research investigated the informal use of two children's digital reference services that were used for purposes unintended by the designers. The motivation for this research was to explore the ways that children bend to their own informal uses the formal tools designed to support their education. Research questions included, How and with what frequency do children use digital reference services to answer their own questions? Do digital reference services support self-initiated learning? Could digital reference services support the transfer of student motivation and curiosity from formal education to informal education? What do instructional and software designers need to consider in creating tools that support a notion of transformed education and learning? Results answered these questions and uncovered several unanticipated findings. Digital reference services were shown to support efforts to interest children in science-related careers as early as fourth or fifth grade and to support self-initiated learning in science. Unanticipated findings showed that students ask different kinds of questions as they progress through school, and they should receive training in the use of digital reference services in elementary school. Further conclusions provide insights for digital reference software and service design and suggestions for more strategic pedagogical use of digital references services.

INTRODUCTION

Children's digital reference services are a form of interactive communication technology (ICT) used to support curriculum-based education. Accordingly, most research focuses on children's use of digital reference

services for imposed queries within a setting of formal learning. In utter disregard for educators' and designers' desires, however, children frequently send unimposed queries to digital reference services to support their informal learning needs. In a discussion of bricks-and-mortar libraries, Riechel points out the importance of considering children's informal use of formal resources: "The completion of homework assignments is all too often perceived to be the only reason to visit the library" (1991, p. xii). He states that a reference service should serve as a "primary source for the fulfillment of all information needs, not just those that are school related" (p. 120). This neglect is even more noticeable—and regrettable—in the study of digital libraries and their digital reference services, which are encountering growing numbers of self-initiated, unimposed queries from children.

The first large-scale recognition of informal learning's importance occurred in 1984, when the National Science Foundation created the Division of Informal Science Education. The division's creation was based on a report that identified museums, libraries, and other community organizations as vital to education (National Science Board, 1983). In the interim, several smaller groups and initiatives have sprung up to address research into informal education. The need and opportunity for study, however, currently outstrip the attention given by scholars. One reason for this dearth of attention is that research on this topic is inherently difficult: it usually relies on children's communication skills to write (in logs), organize thoughts (in interviews), and articulate logical abstractions (in think-aloud protocols). Children, however, possess varying cognitive skills and may not be able to participate in these research methods. The difficulties of this work, however, must be overcome because more than 85 million U.S. children are on the Internet (U.S. Census Bureau, 2001), and, to some degree, their future success depends on their ability to use the Web effectively to find and use information.

The research reported in this article was undertaken to address this shortage of information and to explore Sefton-Green's (2004) notion that research on the use of ICTs for informal learning may reform educational theory and transform the nature of education altogether: "young people's interaction with ICTs outside of formal education is a complex 'educational' experience" that will compel us to redefine "simplistic definitions of learning and education" (Sefton-Green, 2004).

Definitions of Informal Learning

"Informal learning" is one of many terms that have been applied to learning outside of school. It is related to Oldfather's and McCaughlin's (1993) "continuing impulse to learn." Similarly, "interest" is expressed as the degree of interactivity between a student and an object (Livingstone, 2001), with students who have higher interest in a topic capable of

more engagement and persistence (Alexander et al., 1997; Krapp, Hidi, & Renninger, 1992; Schiefele, 1998.) Often, this higher interest is called intrinsic motivation—learning for inherent satisfaction (Ryan & Deci, 2000)—and constitutes a desirable educational outcome in itself (Krapp, 2002; Ryan & Powelson, 1991). Intrinsic motivation requires no gold stars, no grades, and no classroom pizza parties. In fact, such external motivators may inhibit and erode natural intrinsic motivation (Deci, Koestner, & Ryan, 2001). Deci and Ryan (2000) suggest that, when students are encouraged to bring their own experiences and prior knowledge to the teaching setting, they are more motivated to pursue self-initiated learning. Further, self-initiated learning is a defining behavior of lifelong learners and a desirable goal for all students. These descriptions provide a general understanding of informal learning. A more specific description, however, is needed for further research; it is based on two contexts of informal learning.

First, within the context of education, Sefton-Green (2004) defines three kinds of informal learning, all of which occur in nonschool environments: educational experiences provided to support curricula; educational experiences provided to support socially important, but not curriculum-related, learning; and leisure activities outside the realm of socially valued educational experience. The setting for this study is a pair of digital reference services that provide out-of-school information about curriculum-related and socially valued topics—a combination of Sefton-Green's first two definitions.

A second context for defining learning is found in library science, where learning occurs when users pair information needs with search words and query the system, collection, or librarian. Queries that come from students preparing for homework assignments, test preparation, and report writing are said to be "imposed queries" (Gross, 1998). "The imposed query . . . differentiates between information seeking that is self-generated (internally motivated in response to the context of an individual's life circumstance), and imposed information seeking, which is externally motivated, being set in motion when a person gives a question to someone else to resolve . . . such as school assignments" (Gross, 1998, p. 290). Gross's self-generated information seeking may be thought of as an "unimposed query," which is, for the purposes of this research, equivalent to a "Just Curious" query. This study investigates what happens when children use tools originally designed to support the answering of imposed queries to answer their own, unimposed queries in pursuit of informal learning. In summary, and for the purpose of this research, informal learning is defined and operationalized as unimposed queries that children send to digital reference services—services that were originally intended to support only imposed queries directly related to curricula.

Informal Learning and Digital Reference Services

The digital reference service (also known as an AskA service) is an ICT that enables expansion of library services by providing outreach and human intermediation in response to users' emailed queries; it is integral to the digital library (Lankes, 2002). Digital reference services are becoming increasingly specialized to serve specific user populations, one of which is children. An important characteristic of children's services is that they are designed to support learning about specific subjects that are linked to school curriculum topics. For example, Ask A Mummy (<http://www.mummytombs.com/main.questions.htm>) is designed to help children learn about the history of Egypt, which is a component of their curriculum. In another example, Ask Jake the Sea Whale (<http://www.whaletimes.org/whaques.htm>) provides children with expertise about marine biology and zoology—also components of their curriculum. Frequently, however, students use these formal education tools to obtain information about their informal information needs. It is the use of formal digital reference services for these informal information needs that is the topic of this research.

The Research Questions

A casual review in 2004 of questions from a children's science-oriented AskA service—in which it was expected that most of the questions would be science related—showed that many questions were informal and not science related. Upon reviewing some of the data, four research questions evolved:

- How and with what frequency do children use digital reference services to answer their own questions (unimposed queries)?
- Do digital reference services support self-initiated learning?
- Could digital reference services support the transfer of student motivation and curiosity from formal to informal education and learning?
- If so, what would instructional and software designers need to consider in creating tools that support Sefton-Green's (2004) notion of transformed education and learning?

METHODS

The Information Institute of Syracuse at Syracuse University's School of Information Studies supports many digital reference services, two of which are intended for use by students. One is the Virtual Reference Desk's (VRD) Learning Center (<http://vrd.askvrd.org/search.asp>), and the other is a yearly, week-long, digital reference service sponsored by the National Science Foundation (NSF) during Excellence in Science, Technology, and Mathematics Education Week (ESTME) (<http://www.estmeurlhere.com>). ESTME 2004's digital reference service was designed to encourage students' interest in mathematics and science and recruited more than 300 experts

who volunteered to answer almost 600 questions from students, teachers, parents, and the general public. Questions from the VRD's Learning Center and NSF's ESTME week-long service were compiled in one database, processed (as described below in Data Processing), and analyzed using inductive methods (described below in Inductive Analysis).

Data Processing

Both the Learning Center and the ESTME digital reference services provided pull-down menus so users could describe their roles (for example, student, teacher, parent) and the uses to which they would put the answers (for example, written report, science fair project, just curious.) Only questions that were asked by "students" who marked the "just curious" category were kept in the database. Duplicate questions, defined as identically worded queries submitted almost simultaneously, were stripped from the database. Questions that seemed obviously mislabeled were removed from the database for the sake of accuracy. For example, several questions were labeled as being asked by elementary school children, but the wording ("My child wants to know . . .") showed that adults actually submitted the questions.

Questions from students in grades K–5 were coded "Elementary Student." Questions from students in grades 6–8 were coded "Middle School Student," and questions from students in grades 9–12 were coded "High School Student." A total of 114 unique questions (35 from the Learning Center and 79 from the ESTME service) remained.

Inductive Analysis

The 114 unique questions were loaded into HyperResearch, a qualitative software application for inductive analysis. Inductive data analysis requires the researcher to set aside biases from experience and knowledge of the literature and to let the data speak for themselves. Qualitative analysis software was chosen over manual analysis procedures because it enables methodical, replicable, and well-documented analysis of patterns and hypotheses as they emerge from the data.

The decision to use only inductive analysis was reached after a review of the literature, specifically in the domain of question taxonomies. A taxonomy created by Graesser, Lang, and Horgan (1988) potentially seemed the most useful. Upon closer study, however, several aspects of the taxonomy precluded its use in this study. First, it categorized questions articulated by adults, but children do not necessarily ask the same kinds of questions as adults. Second, the questions that work were imposed and based upon assigned readings. The requisite question domain for this study, however, was informal questions stemming from students' self-initiated interests. Finally, in a dry run of coding according to the Graesser, Lang, and Hor-

gan taxonomy, many of the children's questions fell into one and only one category, "Concept completion." This is useful information but not sufficiently descriptive to support a deductive research method. Thus, the deductive approach of existing taxonomies was discarded, and inductive analysis was used for the remainder of the analysis. Inductive data analysis allowed identification of forty-three topics or codes. The co-occurrences of some codes revealed findings that are reported in the next section.

FINDINGS

Inductive coding occurred in two phases, first providing descriptive findings and then unanticipated findings.

First Phase of Coding: Descriptive Findings

The first phase of coding was useful for identifying compound questions, which refined the unit of analysis from user to query, and for showing the informal uses of digital reference services by grade level.

Compound questions and the unit of analysis The original unit of analysis for this research was the individual email that contained the student's question. Many students, however, asked several questions in one email, and most often they addressed different topics. One middle school student asked the following compound question, "What is at the core of the Earth? How do you know what is there because no one or thing has ever gone there?" The two queries in this question are related, but the first query requires a "ready reference" answer, and the second query requires a discussion of geological research methods and the scientific method. The presence of compound questions required changing the unit of measurement from emailed question to the individual query within the email. Within each compound question, queries were coded separately from others in the same email message. The number of emailed questions (114) yielded a total of 150 individual queries. Thirty-two percent of all queries were part of compound questions, and that percentage was evenly distributed across the three groups (elementary, middle school, and high school). Because the total number of queries from each grade level group differs, the remainder of the findings will be presented in percentages.

Use of digital reference services by grade level The first phase of coding also showed use by grade levels. Elementary school students submitted a large portion of the questions, and middle school students asked the most questions (see Figure 1). Older students submitted far fewer questions, indicating that high school students are not currently using digital reference services—a finding confirmed in Silverstein (2004).

In summary, descriptive data resulted from the first phase of coding and created the foundation for the second phase of coding, which generated unanticipated findings.

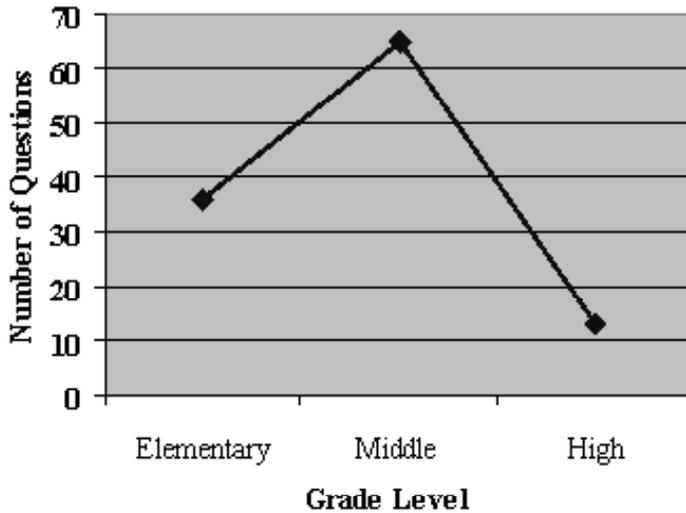


Figure 1. Number of questions by grade level.

Second Phase of Coding: Unanticipated Findings

A second phase of data analysis was based on codes from the first phase and resulted in three groups of unanticipated findings. These findings showed that students used the digital reference services

- for six categories of query foci that shift over time
- to support informal queries related to formal school work
- to ask informal queries about specific topics, including but not restricted to Career Planning, Health and Welfare, and Death and Anxiety

Query foci Each of the 150 queries could be assigned exclusively to one of six categories of Query Focus, including; “My Life,” “My Stuff,” “Other People,” “The World,” “The Universe,” and “Abstract Thought.” These categories are defined in Table 1.

Further analysis showed that the students’ grade levels often correlate with specific query foci. That is, students seem to be interested in certain foci, and those interests may shift over time. Figure 2 shows the number of queries arranged by query focus category and grade level group. Forty-five percent of elementary school queries express interest about how the world works, while middle school students are increasingly interested in abstract or conceptual issues. High school students seem to have the narrowest foci; they are increasingly absorbed in the immediate circumstances and artifacts of their world (“My Life” and “My Stuff”) and less interested as the focus

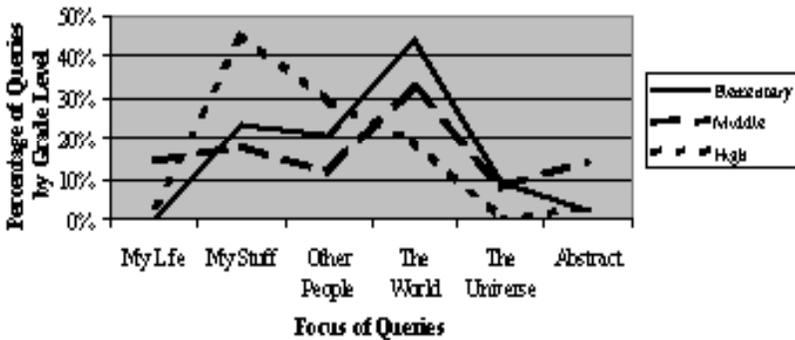


Figure 2. Query focus by grade level.

widens to other people, the world, and the universe. Findings suggest, then, that the topics about which a student is just curious may shift, over time, from “how the world works” to “how my world works.”

It is necessary to point out that the student participants in the three grade-level groups (elementary, middle school, and high school) did not comprise one population observed longitudinally but three separate groups of participants. Thus, this research suggests, rather than claims, that the foci of students’ digital reference queries change over time.

Informal queries related to formal school work “Just Curious” users submitted very few queries that directly addressed “School-Related Learning,” such as, “How do you study for a test?” and “What is 64 divided by .78?” Queries that were coded “School-Related Learning” comprised less than 8 percent of all queries, suggesting a negative correlation between children’s intrinsic curiosity and assigned work.

Table 1. Query Focus Categories and Definitions

Query Focus Code	Category	Definition
My Life		Students’ queries about their families, their health, or their futures
My Stuff		Students’ queries about the immediate circumstances or artifacts of their lives
Other People		Students’ queries about people, alive or dead, about whom the student is curious but to whom s/he is not directly related by family or other personal association
The World		Students’ queries that address nonpeople components of the world or how the world works
The Universe		Students’ queries about space or how things work beyond our world
Abstract Thought		Students’ queries that are philosophical or conceptual in nature

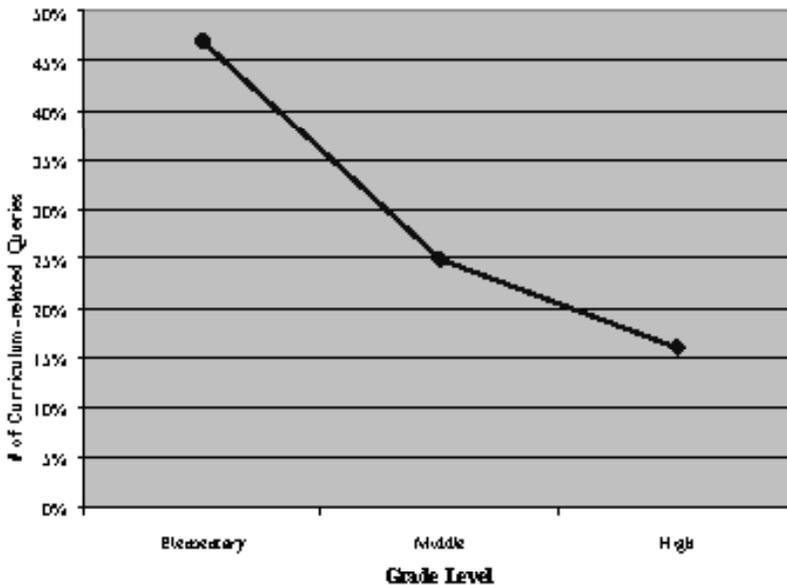


Figure 3. Curriculum-related interest by grade level.

Conversely, the code category “Curriculum-Related Interest” is particularly relevant to informal learning because it indicates that a student’s query was unimposed but may have been stimulated by classroom learning. More to the point, “Curriculum-Related Interest” describes queries that represent curiosity that may have “carried over” from formal learning (extrinsic curiosity) to informal learning (intrinsic curiosity). “I want to know about Hercules. It’s not for school,” is an example of a query that was coded “Curriculum-Related Interest.”

Figure 3 illustrates that “carry over” from the classroom to informal learning is at its highest in elementary school and drops off over time. Again, these findings reflect the interests of three different groups of student participants and only suggest that these changes may occur over time in the same population.

“Curriculum-Related Interest” queries were divided by grade level and subdivided by academic subject (for example, science, language arts, etc.) in hopes of identifying which school subjects most easily “carry over” from the classroom to the informal environment. Since one of the two digital reference services was intended to provide answers only to science-related questions and would have skewed the data, however, this approach was abandoned.

The data did provide an opportunity to examine the percentage of queries that were coded “Curriculum-Related Interest” and were science

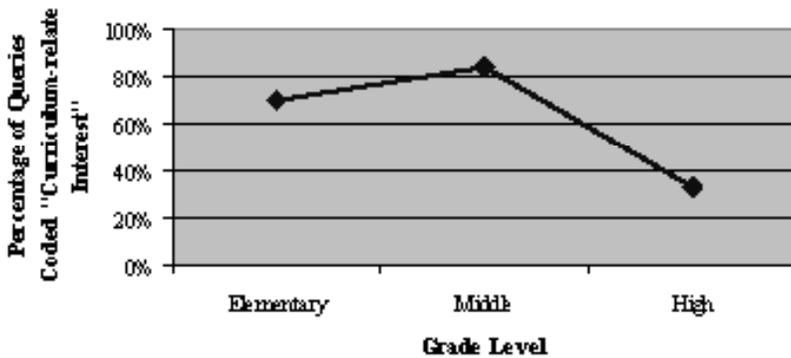


Figure 4. Informal science learning by grade level.

related by grade level. Those data are laid out in Figure 4 and suggest that students' inclination for informal learning about science is greatest in middle school. Out of nineteen "Curriculum-Related Interest" queries asked by middle school students, sixteen were about various aspects of science—the percentage increased steadily through elementary and middle school and dropped away in high school.

Finally, nearly half of all queries from elementary school students were coded "Curriculum-Related Interest," indicating that, during the elementary school years, students' curiosity is more influenced by school curricula than it is in later years.

Informal queries about Career Planning, Health and Welfare, and Death and Anxiety Many queries addressed topics that were not intended to be supported by the digital reference services, and some of those topics appeared in disproportionately large numbers. These topics included Career Planning, Health and Welfare, and Death and Anxiety and were most frequently addressed by middle school students. At that time, for example, some students begin to ask specifically about preparing for a career, submitting queries such as, "I was wondering if you needed to know any mathematical knowledge to become a nurse?"; "Other than being a doctor, what are some other occupations I could do with a medical degree?"; and "I was wondering what education a Marine Biologist must go through, and if they can work to save animals and study them?" Children in this study also asked many informal questions about health-related issues. "How can you tell what kind of sickness you have, how do you know if you are going to die, and what kind of medicine you need?"; "Do personality disorders run in the family"; and "Is there anything you can do to make sure you have a girl when you get pregnant?" are several examples.

Finally, middle school students begin to think about their places in the world and the nature of mortality. Approximately 4 percent of queries expressed curiosity about students' health issues and mortality in general queries ("Why do people die?"; "Why do children get life threatening diseases?") and in more specific queries ("How am I going to die?"; and "Are [you] scared to die?").

A summary of the findings shows that two phases of coding established the unit of analysis and generated both descriptive findings and unanticipated findings as listed here:

- The use of children's digital reference services is high in elementary school, peaks in middle school, and greatly diminishes in high school.
- During the elementary school years, students' curiosity is more influenced by school curricula than it will be in later years.
- During the middle school years, use of digital reference services for informal learning about science is at a peak.
- Over the years of K-12, informal information seeking may shift in focus from a world perspective to a personal perspective.
- Students seemed generally uninterested in pursuing school-related topics solely for the sake of curiosity.
- Students used formal digital reference services frequently to pursue three topics of informal information seeking: Career Planning, Health and Welfare, and Death and Anxiety.

CONCLUSIONS

The original four research questions listed above are addressed in this section. An additional section, "Other Conclusions," describes unanticipated conclusions that are outside the scope of the research questions.

1. How and with what frequency do children use digital reference services to answer their own questions (unimposed queries)?

Elementary school students asked thirty-six "Just Curious" questions, middle school students asked fifty-nine, and high school students asked nineteen. In grades three through eight, student curiosity is stirred by school work, and use of formal services to pursue informal information seeking about science peaks. Late elementary school and early middle school students make the greatest use of services to pursue their interests in the world, which declines soon thereafter. Older students seemed uninterested in pursuing information about school-related topics for the sake of curiosity, but they frequently used formal digital reference services to pursue information about three topics: Career Planning, Health and Welfare, and Death and Anxiety.

2. Do digital reference services support self-initiated learning?

Of all the 2,258 original questions submitted to the two digital reference services in this research, students' unimposed or self-initiated ques-

tions—the ones labeled “Just Curious”—numbered 297. The fact that 13 percent of all questions submitted to two formal services were informal illustrates that students made substantial use of the digital reference services—and indicates that digital reference services do support self-initiated learning, a conclusion not discussed in the literature about digital reference services.

3. Could digital reference services support the transfer of student motivation and curiosity from formal to informal education and learning?

Queries that were coded “Curriculum-Related Interest” represented instances in which school work stimulated students’ need for informal information. This “carry over” from extrinsic to intrinsic curiosity occurred most frequently in elementary grades, when students’ curiosity seemed most deeply influenced by school curricula. Thus, one may conclude that digital reference services can effectively support the transfer of student curiosity from extrinsic to intrinsic, and from formal to informal education, at least for some populations. The literature on digital reference services shows little previous interest in, or findings related to, this fact.

4. What do instructional and software designers need to consider in creating tools that support Sefton-Green’s (2004) notion of transformed education and learning?

Findings uncovered several areas of potential interest to software designers and instructional designers. First, occurrences of duplicate questions may indicate that users are experiencing difficulty with digital reference software or that the software is malfunctioning. Many duplicate questions were received by the two digital reference services that participated in this research. It was impossible to know, however, exactly what kinds of difficulties students encountered in submitting their questions. Consulting with students would help software designers create interfaces that support the students’ information-seeking needs and seem more intuitive to them. This practice has been used successfully in creating children’s online tools and digital libraries (Druin, 2002) and would be helpful in the design of children’s digital reference services.

Second, many questions contained compound queries. This may be a natural tendency, especially as students become cognitively more sophisticated and ask hard-to-answer questions. Software, however, must be “taught” to separate the queries, perhaps refer them to different experts, archive them separately, and yet be able to re-combine them for responding to the student. Multiple referrals would require specialized tracking systems to ensure that users receive complete answers. The topic of compound questions is not widely addressed in the digital reference literature (Lankes, 1999).

Third, results suggest that the elementary school years are optimal for introducing digital reference services. Instructional designers could build on this finding by creating interfaces that support the elementary student’s information needs. For example, it may be possible to create interfaces

that change longitudinally, along with the students, to accommodate personal and cognitive changes as their foci move from how the world works, to abstract issues, and then back to the students' private worlds. One way to approach this daunting task is to include child psychologists in design development for digital reference services. More important, software and instructional designers should work with students, letting them guide the creation of functional specifications, especially with regard for interface design and information retrieval. The concept of longitudinally dynamic interfaces for children's digital reference services is not discussed in the literature.

OTHER CONCLUSIONS

Four unanticipated findings support three miscellaneous conclusions. The first conclusion is that digital reference services should broaden their topical domains to include topics of urgent concern to children, and they must improve services to better answer questions about those concerns. As mentioned in a previous section, students begin to articulate concerns about health and mortality in middle school. This information alone is somewhat interesting but, viewed within the perspective of information provision, it points to a gap in children's online information services. Health worries are not necessarily school related, but addressing them is important to students' abilities to learn. One could imagine, for example, digital reference services that link to various kinds of anonymous counseling services. Children who are ill, or whose parents are ill, could be directed to online support groups with other children or to chat rooms with school counselors, or they could be linked to online sites that provide information about specific illnesses. There is some discussion of children's online health information services in the medical literature, but the connection has not been made to children's digital reference services.

A second miscellaneous conclusion is that digital reference services could support efforts to interest children in science-related careers as early as fourth or fifth grade. Two findings—that middle school students show the most interest in careers, and that they are the most likely group to pursue informal learning about science—support this conclusion. A final miscellaneous conclusion is that elementary school students should receive training in the use of digital reference services, a pedagogical practice that would support the impending middle school burst of interest in using informal learning tools to learn about science.

A brief review of the conclusions shows that they contribute to research and practice: The conclusions that digital reference services support self-initiated learning and the transfer of extrinsic curiosity to intrinsic curiosity have been undocumented in the literature for digital reference services and in the literature for curiosity and motivation in learning. Further, some of these conclusions provide insights for digital reference software

and service design and suggestions for more strategic pedagogical use of digital references services.

LIMITATIONS

Four limitations may have affected the results. First, this research was based on data from two digital reference services. One was designed to answer questions about all academic subjects, but the other was designed to answer only science-related questions. This circumstance skewed the frequency of questions toward science topics. Therefore, attempts to identify those academic subjects about which informal learning most easily “carries over” from the classroom to the informal environment were abandoned.

Second, some data were lost because teachers, librarians, and parents registered as students. The language of these queries (for example, “For a lesson plan I am preparing, I need . . .”) revealed the nonstudent status of the user.

The third limitation to this research only became clear in the data analysis stage. Plotting trends among the three grade level groups (K–5, 6–8, and 9–12) showed distinct similarities among the members within specific grade level groups and distinct dissimilarities between the grade level groups themselves. One could conclude that these patterns change for all students as they proceed through grade levels. That conclusion, however, can only be suggested here and must wait for a longitudinal study to be proven.

Fourth, not all hypotheses could be tested. Within the framework of inductive analysis, hypotheses may be thought of as explanations of relationships among the code categories. Examination of all permutations of the forty-three codes, however, would result in almost nine trillion combinations, each of which would be a potential hypothesis. Instead, only several hundred query combinations were run, and they were based on iterative attempts to find the most fruitful queries. Of those, only the combinations that showed trends and patterns are reported here.

FUTURE RESEARCH

Conclusions from this work have suggested four new questions for future research. First, digital reference librarians need more context than students currently provide if they are to formulate useful answers to students’ questions. Digital reference services allow the exchange of some contextual information, but students rarely provide this information when submitting questions. In some cases—when students ask about career planning, for example—digital reference librarians may feel confident that they know what the user wants and how the information will be used. In most cases, however, librarians do not know what motivated the questioner or how s/he will use the information. Research has not focused on students’ motivation in information systems (Small, 1999). Yet, knowing the user’s objective in

asking a question is critical to determining what kind of information should be provided in an answer (Taylor, 1968). Therefore, it is important to consider that children use digital reference services to ask questions in which their motivations and objectives are not stated. These kinds of queries may signal opportunities for useful educational interventions, such as counseling, referral to other kinds of experts, or mentoring. First, however, future research must provide a means for including context in students' questions and must address the research question, "How can digital reference services capture and integrate the context of students' questions?"

A second topic for future research is determining how students' needs for digital reference services change over time. Findings have shown that the foci of student queries shift over time. Can designers create software that automatically, dynamically, and longitudinally supports those changing needs and encourages self-initiated learning?

Third, this research has shown that digital reference services support science learning, particularly in middle school. Future researchers might consider the question, "How can digital reference services support learning of other academic topics, and in other age groups?"

Fourth, one finding of this research showed that children may be experiencing difficulties operating digital reference software. A result was the submission of duplicate questions, and a suggested solution was that software designers consult with children. Other findings show that children ask specific kinds of questions, which implies that their digital reference systems should not necessarily be modeled on those designed for adults. These observations suggest that future researchers should address the question, "How can we include children in our research and enable them to contribute to the design of their own digital reference services?"

SUMMARY

The goal of this study was to investigate the unintended use of children's digital references services for informal learning and to determine how resulting knowledge could benefit the users and designers of those services. The findings and conclusions indicate that a deeper understanding will benefit software and instructional designers. They may wish to consider ways to create software that supports informal as well as formal learning. More specifically, they may wish to consider creating student-reflective services that are co-designed with the students and that change along with them.

Deeper understanding will also benefit digital reference librarians and classroom educators, who can use digital reference services to support and stimulate students' intrinsic curiosity beginning in elementary school. Most important, students will benefit by having at their disposal—at any time and place—tools that reflect their information-seeking needs and enable contact with experts who can answer their questions—both formal and informal. It is hoped that conclusions from this research will contribute to

the literature about digital reference services and to the literature about curiosity, ultimately improving the ability of digital reference services to sustain students' continuing impulse to learn.

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