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ABSTRACT

The Portals project examined the roles, functions, and strategies that students, teachers, and mentors bring to complex on-line, project-based learning experiences. Data for the study consisted of site observations, interviews, student work samples, and videotaped project presentations from twelve project-based mentoring relationships that were conducted entirely or partially on-line. From these data, the study identified approximately 30 strategies/functions exercised by students, mentors, and teachers in creating and maintaining on-line mentoring relationships. The study then classified these strategies/functions according to Levin's (1995) taxonomy for describing and supporting networked educational interactions. Levin's categories include: structure, process, mediation, community building, and institutional structure. The paper concludes with recommendations for improving telementoring designs. (Contains 18 references.) (Author/ASK)

Portals: A Window into Telementorinig Relationships in Project-Based Computational Science Classes

by

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Portals: A Window into Telementoring Relationships in Project-Based, Computational Science Classes

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Abstract: This paper describes novel research that we conducted as part of the Portals project (NSF Grant #CDA-9616990). We examined the roles, functions and strategies that students, teachers, and mentors bring to complex on-line, project-based learning experiences. Data for our study consisted of site observations, interviews, student work samples and videotaped project presentations from twelve project-based mentoring relationships that were conducted entirely or partially on-line. From these data, we identified approximately 30 strategies/functions exercised by students, mentors and teachers in creating and maintaining on-line mentoring relationships. We then classified these strategies/functions according to Levin's taxonomy for describing and supporting networked educational interactions. Levin's categories include: Structure, process, mediation, community building, and institutional structure. We conclude with recommendations for improving telementoring designs.

Key words: Mentoring, Learning environments, Computer-mediated communication.

Introduction

Mentoring has long been recognized as an important form of teaching and learning, and a great deal of research has been conducted on the topic. Studies of mentoring in undergraduate and professional education and management settings over the last 20 years have identified several key factors that shape and define mentoring relationships. These include: the duration of the relationship (long-term vs. short-term); whether the relationship was organized "formally" or "naturally;" the goals of the relationship; and the various roles and functions that mentors exercise (Jacobi, 1991; Welch, 1996). These studies, however, could not have anticipated the rapid rise of the Internet or its implications for mentoring opportunities in primary and secondary education.

As Internet access has become more prevalent and reliable in schools, opportunities have proliferated for individuals who are *not* classroom teachers to mentor, guide, evaluate and become involved in the education of young people. Described on the web are a number of initiatives to connect students with potential mentors for academic or psychosocial support and assistance. A sampling of these includes: Imentor, Hewlett Packard's E-mail Mentor program, CCT's Telementoring Young Women in Science, Engineering and Computing project, the University of Texas's Electronic Emissary project, Project Estrella, and BBN's MentorCenter. Despite these and other initiatives, still relatively little is known about how mentors and students interact on-line and what is needed to ensure that such interactions are meaningful and useful for the students.

Our research attempts to extend the present corpus of knowledge on this subject by identifying and characterizing the roles and strategies employed by students, teachers, and mentors in creating successful on-line mentoring relationships. In this work, we build upon several recent studies of telementoring, including those of

O'Neill (1998); Bennett, Hupert, Tsikalas, Meade & Honey (1998); Polman & Pea (1997); and Harris (1995). Additionally, we use Levin's (1995) key components of network-based learning environments as a framework for analyzing and classifying our observations.

This paper describes novel research that we conducted as part of the Portals project (NSF Grant #CDA-9616990). In Portals, we examined twelve project-based mentoring relationships that were conducted entirely or partially on-line. These mentoring relationships involved 40 high school students, 5 teachers, and 12 mentors. Classes were located in Iowa and Tennessee and were part of the Adventures in Supercomputing (AiS) program, which is supported by the Department of Energy.

Students participating in AiS classes worked collaboratively with other students and mentors for one to six months to develop computational science projects. Examples of their projects include:

- A computer program to help farmers assess the best type of irrigation system for a particular piece of land, taking into account the type of crop being cultivated, the availability of water in the area, and the pros and cons of different types of systems on the market. To create this program, students worked with a county natural resource manager.
- A computer program to predict the rates of growth for different kinds of coral reefs, given the type of coral, its depth, water temperatures and other characteristics of the marine environment.
- A simulation to determine whether the archeopteryx (the winged dinosaur) was capable of flight. To build this simulation, students worked with two mentors, a paleontologist and a physicist, and developed both a physical and a computational model for this study.
- A computer program to predict the future incidence of various types of cancer. To create this program, students worked with officials from their local chapter of the American Cancer Association to gather and interpret relevant statistics and to integrate them with new developments in prevention and treatment.

At the time of the Portals project, CCT had conducted evaluations of student learning in the AiS program for three years. These evaluations had established that nearly 80% of AiS students worked with mentors (on-line and off-line). They also indicated that AiS teachers and students cited mentors as being particularly important in helping students to: (1) shape research interests into tractable problems for investigation; (2) develop mathematical models to represent these research problems; and (3) draw meaningful project conclusions from numerical data and scientific visualizations (Honey et al. , 1994; Honey et al. , 1995).

Data for the Portals study of on-line, project-based mentoring consisted of mid- and post-project site observations and interviews with teachers and students, post-project interviews with mentors, student work samples and videotaped project presentations. Using a three-stage analysis process, we identified the roles and functions employed by teachers, mentors and students to develop effective relationships. We analyzed these within the frameworks of mentoring (Bennett, Hupert, Tsikalas, Meade & Honey., 1998; Jacobi, 1991; O'Neill, 1998; NAS, 1997; Sullivan, 1994), cognitive apprenticeship (Collins, Brown, & Newman, 1989; Scardamalia, Bereiter, & Steinbach, 1984), and educational network interactions (Levin, 1995). Additionally, we introduced a web-based tool (Portals) to facilitate more effective communication in such mentoring situations and documented how and when it was used.

Contexts

<u>Classes</u>. Twelve projects from five different classes were researched as part of this study. Four of the classes were located in Tennessee and one in Iowa. Four were rural and one class was part of an urban school. Three of these

classes were technology-rich, providing students with access to several up-to-date computer workstations (both Macintosh and PC) with ample RAM and processor speed and reliable Internet connectivity. In these classes, the technology itself was not an impediment to working on the web or with mentors remotely, through Portals or otherwise. The remaining two classes were less fortunate; they had three or four computers which were 4-5 years old. In both of these classes, only one machine had the RAM-capacity to run a java-enabled web browser, and in one class, only one of the four workstations was connected to the Internet.

Teachers. Three of the five teachers in our sample were male, and two were female. Two teachers taught computer applications and programming courses as their primary subjects. The other three taught science courses in addition to the AiS computational science classes; they taught chemistry, biology, and physics respectively. All five were veteran AiS teachers, having taught the course for 3 or more years. However, one teacher had not previously taught the class on her own, but rather as part of a team.

Most of the teachers described indicated that they taught on a "need to know" basis. With the exception of basic programming and Internet (e-mail and web) competencies, they introduced concepts and skills when students needed to learn them to develop their project work. However, each approached the project and mentoring differently. For example, one teacher was very involved in the scientific content of her students' projects. Rather than relegating content responsibilities to mentors, as was often the case, this teacher carefully read most of the same texts that her students did. She took notes, highlighted passages, shared her observations with the students, and required them respond at weekly conferences. Another teacher enjoyed the increased opportunities for visualization provided by technology and urged his students to create many different kinds of graphs and illustrations to represent their project questions and data. Three of the teachers placed a great emphasis on peer support and mentoring.

Mentors. All participating mentors were male. Four were scientists, computer scientists or engineers in state or federal government positions; four held similar jobs in private industry; two mentors were university professors; and one mentor was the director of a non-profit research and education institute.

Most of the mentors (n=8) were discovered by the students through Internet searches or letters of inquiry; four were obtained via personal connections of the students themselves, their teachers or their parents. Half of the mentors (n=6), but not necessarily those acquired through personal connections, interacted with their student groups through a combination of in-person and on-line modalities. The remaining 50% interacted entirely from a distance using both the Internet and fax/telephone conferencing technologies.

Students. Thirty nine students participated in this Portals research. Twenty-one (54%) of them were male and 18 (46%) female. Two-thirds of the students (n=26) were in the tenth or eleventh grade; ten students (26%) were twelfth grade and one was in the ninth grade. Nearly 85% of these students (n=32) had a computer in their home; about two thirds (n=25) also had Internet access from home. All of these students worked on their AiS projects as part of a team; there were no individual projects in our sample.

Among the twelve project groups in this study, seven were comprised of both males and females; two groups were female-only and three were male-only. Most groups were comprised of two, three, or four students. Only one team consisted of five students.

The team's project topics and key questions/goals included:

Project Topic	Key Question or Goal
Antimatter Galaxies	Do antimatter galaxies exist and how can we prove or disprove their existence?

Condors	How do large birds fly? Do large birds fly more efficiently than small ones? What are condors like?
Levitrons	What is the position at which the floating levitron is most stable?
Lightning	Which powerlines in the vicinity need more protection from lightning? How is this protection best provided?
Pharmacokinetics	To model the metabolism of nicotine derived from second-hand smoke in the human body.
Sea Turtles	To determine how and to what extent natural factors affect the population of endangered sea turtles.
Severe Storms	To create a model to predict the likelihood of severe weather.

Findings about Strategies/Functions Exercised by Participants in Telementoring Relationships

We characterized approximately 30 student, teacher, and mentor strategies/functions using a three-stage analysis process. This process included:

1. Identifying strategies by analyzing transcripts of interview and student presentation data;
2. Refining, revising and grouping strategies by developing case stories that captured the essence of our 12 telementoring cases;
3. Testing strategy groups by applying them to interview and student presentation data.

We grouped the strategies and functions that we identified in our evidence according to a taxonomy proposed by Levin (1995). Levin derives his taxonomy from a review of guidelines, established by a range of researchers and program developers, for supporting and structuring communication among collaborators in on-line educational activities. He identifies five general features commonly discussed in the various guidelines he reviews:

- Structure: Creating clear guidelines about who communicates with who, for what purposes, how frequently, and in what ways. This is important to successful communication because on-line interactions differ from more familiar face-to-face interactions and cues to support spontaneous learning and induction into the community are lacking.
- Process: Making explicit the phases of purposes, tone, or intensity that a conversation is expected to move through over time. This element is important as a way of acknowledging and responding to the "slow motion" unfolding of on-line communication and its very different time frame, compared to face-to-face communication.
- Mediation: Setting clear and specific roles and expectations for an individual or group that will guide, supervise, and support the communication process. Levin identifies weakness in this area as the most common cause of dissolution of on-line communities.
- Community-building: Sharing materials, activities, or messages to promote a shared sense of purpose and benefit regarding participation in the on-line community. Levin points out the particular importance of this element when communication is happening voluntarily and participants are absorbing the costs of their time and effort.
- Institutional structure: Ensuring that there is some organizational support that will allow the community to be sustained and supported over an appropriate length of time.

In regard to each of these features, Levin emphasizes the need for explicitness, for shared responsibility and mutual agreement, and the importance of addressing and reflecting on the particular constraints, as well as the advantages, of on-line communication.

The first four of these proved most useful in describing the strategies that students, mentors, and teachers used in our research.

Structural strategies and functions. Students did not tend to perform structural functions in the telementoring relationships we studied. Instead, these strategies were generally enacted by teachers and mentors.

Teachers structured *student-to-student relationships* in the projects. For example, two of the teachers in our study specified roles for student project groups and required that each student take responsibility for a specific role in the group. One of these roles was *mentor correspondent*. The student who assumed this role was charged with communicating with the mentor about group progress and questions and issues related to the project. Occasionally, students shared this role. In some cases, we observed that the designated mentor correspondent was the least well informed student in the group about the scientific and mathematical details of the students' proposed model. In other words, student groups sometimes designated their good writers to be mentor correspondents, but these individuals were not necessarily the ones most intimately involved with the science, math, and programming parts of the project. Hence, they sometimes had difficulty communicating these aspects of the project to their mentors.

With the AiS curriculum as a basis, teachers in our study also set the *activity structure* in which telementoring relationships occurred. O'Neill (1998, p. 54) defines the ideal activity structure as a "set of roles and responsibilities for students, telementors and the teacher, connected to a schedule of deliverables." In the relationships we studied, the structure did not tend to include teacher and mentor roles and responsibilities. However, it did include a set of deliverables and deadlines for student work.

Mentors, on the other hand, often structured the *process of project development*. They counseled students on what actions needed to be taken in order to complete the deliverables by the required deadlines. For example, one mentor provided his group with a sequence of tasks that they must accomplish in order to finish their project. He carefully annotated each step with the equations that they would need to apply. Another mentor asked students to prepare a set of possible project topics. In a conference call, the mentor and students discussed the pros and cons of each idea, and the mentor commented on what he thought would be involved in bringing each one to a successful conclusion.

Reflecting on both of these telementoring experiences, the students' teacher: "I'm starting to see as I have more projects behind me, that some of these mentors want to have this on-going kind of conversation with the student and work with them to develop their project. Others want to have a planing mind, teach the kids what to do, then out... We're probably going to have to accommodate both styles."

Process strategies and functions. In contrast to the situation regarding structure, students exercised a number of process strategies in developing and sustaining their telementoring relationships. Students:

- Defined a specific role for their mentor in their project. For example, one pair of students began the relationship by telling their mentor what they wanted to do and what they wanted him to do. Another group restricted their mentor's role to content research and comprehension; they did not invite or involve him in the development of their computer model.

- Set expectations. For example, one pair of students introduced themselves to their mentor by listing all their past achievements. They wanted him to know that they were capable of sophisticated work.
- Asked good questions. Some students created novel representations of their thoughts, e.g., a "mental snapshot," that helped them to asked conceptual questions that went beyond the typical, "Is this right?"
- Built a personal relationship with the telementor. Some of the students in this study formed close, interpersonal relationships with their mentors in which they shared experiences about their lives, goals and problems.
- Actively managed communication. Students deliberately selected specific media (chat, web pages, e-mail, Portals) to communicate about certain topics.

Mentors also performed a variety of process functions in these telementoring relationships. They:

- Assessed and anticipated students' needs. For example, one mentor thought his group might be more comfortable talking with a younger person about some of their project problems, so he assigned one of his graduate students to be a project liaison.
- Focused and redirected students to more promising options. It was common for mentors to help students focus and simplify their project topics. Additionally, some mentors recognized errors in the way that students were proceeding and redirected them. For example, one mentor observed that his team was representing their data in a way that would not facilitate meaningful interpretation. He advised them to create graphs at higher resolutions and in response to specific questions.
- Provided information. All mentors supplied content, including articles, sample code and useful URLs.
- Stimulated students to acquire new knowledge through questioning. Many mentors asked questions of the students and encouraged the students to ask them questions. Some mentors posed hypothetical situations in order to encourage students to think beyond the box.
- Directed action. Mentors often selected the method students would use to model their problem of study.
- Extended students' vision of their projects. Many mentors spent considerable time communicating with students about larger scientific constructs, such as hypothesis building and validating findings. The mentors saw this framing as being an extremely important aspect of their role.
- Exercised quality control. Some mentors approved or rejected students' data and interpretations. When student work was not deemed accurate or correct, it was generally returned with suggestions for revision.

Teachers were not so involved with the process of telementoring in the 12 relationships we studied. However, most of the teachers did have a hand in guiding the recruitment of mentors. It was common for teachers to work with their classes to draft a letter that all groups would then send to prospective mentors.

<u>Mediation strategies and functions</u>. Though they were less actively involved in the process of telementoring relationships, the teachers in our study did play a big part in mediating the relationships--both the content and the human relationships. Teachers:

- Explicitly supported and recognized the importance of communication. For example, some teachers *rehearsed* with their students important conversations that would late take place on-line or on the telephone with their mentors.
- Mediated content by reviewing, digesting, and re-teaching. All teachers performed this function, though to varying degrees. One teacher, for instance, read and annotated articles that her students' mentors had provided. She later reviewed the articles, including her own comments and questions, with the students.
- Redirected from impasses. Teachers often helped students restructure their project approach when they did hear from their telementors for several weeks.

Related to mediation, some students again managed communication by selected the media (e-mail, web pages, chat, etc.) that would best convey their thoughts and issues. Similarly, some mentors attended to the communication itself by monitoring their response time and being careful to reply to students' messages within a certain time frame.

<u>Community building strategies and functions</u>. Students, teachers, and mentors all exercised important strategies related to community building. Students tended to do so by building strong collaboration within their teams. For example, in one group, students explicitly stated the value of the youngest person on their team. They stated that this student helped them ask honest questions, "where people who've done a lot of science overlook things." Teachers did so by promoting a climate of collaboration, both internal and external, in their classrooms. For instance, many teachers directed students to share information and even mentors with other students in the class. Other teachers invited former students to participate in their classes as mentors or guest lecturers.

Mentors contributed to community building by:

- Socializing students into particular cultures. For example, one mentor advised students about how they should present themselves when approaching particular scientific institutions for information.
- Treating students as colleagues. For instance, one mentor planned to cite students as co-authors on a paper he was writing.
- Providing acceptance, support and encouragement. Many mentors cultivated a positive affect in their students. They emphasized the importance of enjoying the work and focused on what students had done well.
- Referring students to other people who might be able to assist and support them.

Discussion: The Importance of Teacher and Student Action in Creating Successful Telementoring Relationships

Mentoring is a notoriously fluid and idiosyncratic activity (Sullivan, 1992; Welch 1996) and not easy to define scientifically. Jacobi (1991) reports a number of problems associated with the absence of a widely accepted operational definition of mentoring. O'Neill (1998) suggests that this diversity in types of assistance and support provided may itself be the defining characteristic of mentoring. Given the lack of consensus on a definition of mentoring and telementoring, defining successful telementoring experiences proved similarly challenging.

However, in the Portals research, we chose to adopt the language of the National Academy of Science and defined successful mentoring as the development of relationships that "advance the educational and personal growth of the student (NAS, 1997)." This broad definition--which encompasses psychosocial, career, and academic functions (Jacobi, 1991)--best reflected the goals of the teachers in our study. These teachers indicated that they hoped telementoring experiences would provide their students with:

- access to scientific content expertise that extended beyond their own;
- experience with how real scientists make choices about research questions, methods, data presentation, and data interpretation;
- exposure to a variety of scientific careers and the personal side of science; and
- opportunities to learn to communicate with adults in the real world who weren't their parents or teachers.

To assess the success of the telementoring relationships in our study, we considered four factors--the satisfaction that students, mentors, and teachers reported with the quality of the mentoring interaction; and the extent and quality of student learning that occurred in the projects. Student learning was assessed by an analysis of students' videotaped project presentations. We used a rubric that had been developed for, tested and refined with the AiS program (Honey et al., 1994; Honey et al., 1995). This rubric characterizes learning along the parameters of understanding, critical thinking, clarity of communication, teamwork, and technical understanding. In our analysis, two researchers viewed each of the presentation videotapes, assigned independent scores for each parameter and then discussed and came to consensus on the final project rating.

In examining these data, we determined that there was no specific combination of strategies that led directly to success. However, certain actions on the part of students and teachers tended to be highly related to effective mentoring relationships.

<u>Student actions</u>. Confirming O'Neill's (1998) assertion that students in telementoring relationships are often in positions of greater control than mentees in typical mentoring relationships, we observed that students had a great deal of influence over the form and quality of their telementoring experiences. When students were *aware* of their own needs for specific kinds of assistance and support and when they were *proactive* they were in seeking this specific assistance, their on-line mentoring relationships were more successful.

For example, Sophie and Adam--a pair of students researching how nicotine from second-hand smoke is metabolized in the body--were very self-directed and communicative. When introducing themselves to their mentor, these students described their past achievements and what they hoped to accomplish with their current project. They asked questions specifically about how he might be able to help them create a computational model this situation. They initiated conversations several times a week with him using a variety of media, including e-mail, chat and web pages. They posted data for him to see on a regular basis. All participants in this telementoring relationship were happy with the experience and evidence suggested that the students learned a great deal from these project interactions.

In contrast, when students were unable or unwilling to communicate what they understood, did not understand, or did not understand the importance of, their relationships suffered. For instance, one project group that was investigating the mechanics of the levitron (a small device that resembles a spinning top and appears to levitate when perched atop a magnetic pedestal) withheld information from their mentor about the fact that they were unable to get the device to work and that they did not understand the equations he had sent them. A student on the team reflected: "We were embarrassed to admit our weaknesses to him, and we didn't want him to feel like he had to take hours off his work and explain this to us in real simple terms... I think we didn't want to let him down."

The group's mentor fully expected the students to have questions and need assistance, but he was unprepared for their inability or unwillingness to effectively represent what they didn't understand. Nor did he anticipate a culture in which pleasing the adult could take precedence over learning:

> What they [the students] should be encouraged to do, is to formulate their questions, formulate their concerns, and be quite willing to be honest and say, "We're lost" or "This is boring, and please explain why we have to do it." You know, they should be able to be a little bit more honest about what it is that is holding them up or why things aren't going they way they might want to go. Now, in direct contact, those kinds of messages are much more easily conveyed. But by e-mail, it's different... It's extremely difficult.

__Teacher actions__. We found that teachers were critical facilitators of on-line mentoring relationships in the project groups we studied. They did this by creating structures to facilitate mentoring, by mediating students' interactions with content and humans, and by building community. Our research suggested that two teacher strategies were highly related to successful mentoring relationships:

- Creating a classroom culture of collaboration among students and between students and many external resources. (Community building strategy)
- Explicitly attending to students' communication skills and needs by rehearsing important conversations and by providing opportunities for students themselves to teach or mentor. (Mediation strategy)

For example, one of the teachers in our study consistently encouraged young people to use each other as resources and to enlist the help of as many external people as possible. His was one of the few classes in which it was common for project groups to have several mentors and to work with these different experts simultaneously or sequentially depending on their needs. The practice of using multiple mentors is encouraged by the National Academy of Sciences (1997) and Association for Supervision and Curriculum Development (1994).

Students in this teacher's class also were assigned to manage hardware and software. They were treated as experts and were expected to help each other. Consequently, these students seemed to go first to other students when they had questions or needed help. They also shared resources: One project group obtained their mentor from another AiS team in the class.

This teacher also placed great emphasis on students' communicating in as many ways as possible with their mentors, and he developed practical ways to support these exchanges. He provided one mentor with an account on the school's server so that he (the mentor) could easily view students' computer code while simultaneously chatting with them. Similarly, he encouraged students to use multiple representations, most notably graphs and illustrations, when communicating with their mentors. About communication, this teacher remarked, "We know we need to be more aggressive. We can't just sit back and wait for them to ask us questions. We have to tell them what we know and tell them how we found out."

Conclusions and Recommendations for the Design of Telementoring Environments

In the Portals research, we examined the roles/functions and strategies that students, teachers, mentors and technologies bring to complex on-line, project-based learning experiences. From this work, we have drawn three major conclusions about the creation and maintenance of effective telementoring relationships.

I. <u>The importance of students who are pro-active and prepared for on-line mentoring relationships</u>. While the mentoring literature emphasizes the importance of mentor training and preparedness in successful relationships (Bennett et al., 1998; Harris, 1995; NAS, 1997; Sullivan, 1994), our case studies of 12 project-based telementoring relationships indicated that students had a great deal of control in their telementoring relationships. Our research also suggested that mentors often bumped into brick walls very quickly if students did not know how to communicate effectively on-line or were unwilling to express their needs and weaknesses. Given the importance of students being aware and proactive in telementoring relationships, we recommend that *students* be better prepared for on-line mentoring relationships. Such preparation might include:

- Assuring students that while it may seem counter to what they've experienced in their schooling, being open and honest with their mentors about what they do and do not understand as well as what does and does not interest them is essential for a successful relationship;
- Providing opportunities for students to practice describing (in text) what they do and do not understand about a problem as well as when they're losing steam;
- Providing opportunities for students to receive feedback (e.g., through peer or teacher critiques) about these communicative acts; and
- Educating students about the various roles/functions mentors may exercise in helping them with their projects.

Additionally, our research suggested that student teams that were able to communicate and collaborate well with each other were also able to do so more effectively with telementors. While this finding may simply indicate that good communicators are good communicators regardless of their "audience," it may also imply that the team relationship could serve as a microcosm for the telementoring relationship. Hence, helping students to develop strong teams could improve their potential for success with on-line mentors.

II. <u>The importance of teachers as co-mentors</u>. Past research has stressed the need for facilitation in telementoring relationships (Bennett et al., 1998; Harris, 1995), and our research indicated that teachers were especially important facilitators. Teachers tended to act as co-mentors in particularly important ways: They provided students with opportunities to themselves be mentors; helped students develop effective communication skills; and coached students on "how to construct good questions and summaries... and critiquing their efforts" (Collins, pg. 461).

This role of teachers is seldom recognized by mentors in the interactions: Many of the mentors in our study indicated that they did not know how the teachers contributed to the projects beyond enforcing deadlines. In such, it is incumbent upon teachers to honor and explicitly state their own responsibilities and activities in facilitating students' learning in telementoring relationships. Similarly, on-line structures and software that are designed to support telementoring relationships should recognize and support this role of teachers.

III. <u>The importance of expanding mentors' conceptions of their own roles and functions in telementoring relationships</u>. The mentoring literature specifies a number of roles that mentors may assume in their interactions with students. These include the roles of: Advisor; coach; role model; friend; parent; tutor; skills consultant; career counselor; and critic (Ganser, 1994; NAS, 1997; Sullivan, 1994). Jacobi (1991) further catalogs mentoring functions, including: Providing acceptance, support, or encouragement; Offering advice or guidance; Helping mentees to bypass bureaucracy or gaining access to resources; Challenging mentees providing access to new opportunities or "plum assignments;" Helping mentees to clarify their values or goals; Coaching; providing information; role modeling; socializing mentees into particular cultures; sponsoring or advocating for mentees; stimulating mentees to acquire new knowledge; and training or instructing.

Our research suggested that mentors were rarely aware of the panoply of roles/functions they might employ. Particularly in on-line relationships, mentors sometimes forgot the importance of making their own thinking transparent, so that students may acquire not only domain knowledge but also heuristic and control strategies, such as how to make decisions about how to proceed in a task (Collins, 1989). Our research also indicated that on-line mentors often made assumptions about the classroom culture and the work habits of students that did not reflect reality.

In addressing these issues, we recommend that telementors be made better aware of their multiple roles/functions in these relationships--particularly, of the importance of making their thinking explicit. Additionally, we suggest that on-line mentors be better informed about the students with which and settings in which they are working. This type of information and feedback might best delivered by teachers at regular moments in the mentoring relationship.

References

Bennett, D., Hupert, N., Tsikalas, K., Meade, T., and Honey, M. (1998). *Critical Issues in the Design and Implementation of Telementoring Environments.* New York, NY: Center for Children and Technology, EDC. Also http://www.edc.org/CCT/cctweb/public/.

Collins, A., Brown, J.S., and Newman, S.E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In *Knowing, Learning and Instruction: Essays in Honor of Robert Glaser* (L.B. Resnick, ed.). Hillsdale, NJ: Erlbaum.

Ganser, T. (1994). *Metaphors for Mentoring: An Exploratory Study.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

Honey, M., McMillan, K., Tsikalas, K., and Grimaldi, C. (1994). *Adventures in Supercomputing 1993-94 Evaluation: Final Report.* New York, NY: Center for Children and Technology, EDC. Also http://www.edc.org/CCT/cctweb/public.

Honey, M., McMillan, K., Tsikalas, K., and Light, D. (1995). *Adventures in Supercomputing 1994-95 Evaluation: Final Report.* New York, NY: Center for Children and Technology, EDC. Also http://www.edc.org/CCT/cctweb/public.

Harris, J. (1995). Organizing and facilitating telecollaborative projects. *The Computing Teacher*, 22(5), 66-69.

Jacobi, M. (1991). Mentoring and undergraduate academic success: A literature review. *Review of Educational Research*, 61 (4), 505-532.

Kerka, S. (1998). *New Perspectives on Mentoring.* ERIC Digest No. 194. Columbus, OH: ERIC Clearinghouse.

Lenert, K.F., & Harris, J.B. (1994). Redefining Expertise and Reallocating Roles in Text-Based Asynchronous Teaching/Learning Environments. *Machine-Mediated Learning*, 4 (3).

Levin, J. (1995). *Organizing educational network interactions: Steps towards a theory of network-based learning environments.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco.

National Academy of Sciences (1997). *Adviser, Teacher, Role Model, Friend: On Being a Mentor to Students in Science and Engineering.* Washington, DC: National Academy Press. Also http://www.nap.edu/readingroom/books/mentor.

O'Neill, D.K. (1998). *Engaging Science Practice Through Science Practitioners: Design Experiments in K-12 Telementoring.* (Doctoral Dissertation, Northwestern University, 1998.)

Pea, R. (1994). Seeing what we build together: Distributed multimedia learning environments for transformative communications. *The Journal of the Learning Sciences*, 3(3), 285-299.

Pea, R., Edelson, D., and Gomez, L. (1994). *The CoVis Collaboratory: High school science learning supported by a broadband educational network with scientific visualization, videoconferencing, and collaborative computing.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco.

Scardamalia, M., C. Bereiter, and R. Steinbach (1984). Teachability of reflective processes in writing composition. *Cognitive Science*, 8, 173-190.

Sullivan, C.G. (1994). *How to Mentor in the Midst of Change.* Alexandria, VA: ASCD.

Welch, O.M. (1996). *An Examination of Effective Mentoring Models in the Academy.* Paper presented at the Annual Meeting of the American Educational Research Association, New York.

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