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ClassNet: a potential computer-mediated communications learning tool in preservice teacher education?

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ClassNet: A potential computer-mediated communications learning tool in preservice teacher education?

by

Mark Jay Van Gorp

A dissertation submitted to the graduate faculty in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY

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GENERAL INTRODUCTION

Background

In the 1970s and early 1980s, a revolutionary partnership emerged between the fields of computer science and data communications (Stallings, 1994, p. 1). The development of this alliance, also known as computer-mediated communications (CMC), continues to progress and is profoundly transforming the nature of education (Riel & Harasim, 1994, p. 91). Classrooms of teachers and students are now moving into the virtual world where face-to-face communication is no longer a requirement and geographic location and scheduled meeting times are no longer constraints.

Unfortunately, the evolution of virtual classrooms has lead to classroom management difficulties. Contemporary CMC tools (e.g. e-mail) are simply not designed to handle the numerous and diverse classroom management tasks such as course registration, gradebook management, assignment submission, and intra-class communication. In response, a new Web-based classroom management tool was designed to handle these tasks. This tool, known as ClassNet, is presently being utilized by many students and teachers whose classrooms are either partially or completely online. ClassNet supports their management needs and continues to evolve as additional management requests arise and tool improvements are explored.

However, the educational implications of ClassNet are much broader than classroom management. In concurrence with Hiltz (1993) and Berenfeld (1996), it is apparent that software supporting virtual classrooms can provide learning opportunities that go beyond traditional classrooms — even beyond modern classrooms making extensive use of e-mail and conferencing activities. With this in mind, one of ClassNet's earliest accomplishments provided meteorology students with opportunities to forecast the weather. Now, students experience weather forecasting
each semester by utilizing ClassNet, their classroom knowledge, and meteorological information available from the World Wide Web.

Rationale

While thinking about this learning experience in meteorology and ClassNet's independent support of subject domains, the usefulness of ClassNet in preservice teacher education was considered. Because ClassNet provides authentic opportunities for meteorology students to think like meteorologists, it may also provide preservice teachers with authentic opportunities to think like teachers. These learning opportunities could go beyond what is possible with existing CMC tools such as e-mail -- the primary tool used by education faculty (Greene, Robbins, Riley, Barnes, 1995). Further, ClassNet could help meet the needs of technology integration into the preservice curriculum (Byrum & Cashman, 1993) and the call to create meaningful experiences which allow preservice teachers to construct knowledge of students and subject matter (Darling-Hammond, 1992). Subsequently, this thinking provided the impetus for the dissertation and its collective exploration of CMC, ClassNet, and the education of preservice teachers.

Dissertation Organization

This dissertation is organized according to Iowa State University's alternate format. Following the introduction, three publishable papers (manuscripts) will collectively explore CMC, ClassNet, and preservice teacher education. The thread tying these papers together will be the documented need for a new tool such as ClassNet in preservice teacher education, a description of ClassNet's design and utilization, and an evaluation of ClassNet's usefulness with preservice teachers. The design paper has already been published, and the other two will be submitted to scholarly journals. Any figures will be included after the reference sections in each
paper, and the dissertation will close with a general discussion of the three papers and the need for future research.

The first paper, "Computer-Mediated Communication In Preservice Teacher Education: Surveying Research, Identifying Problems, And Considering Needs", examines the integration of CMC into preservice teacher education. In addition to providing an overview of CMC utilization by faculty, it also analyzes difficulties that have occurred and assesses needs that have emerged. In particular, two basic needs are the investigation of learning that occurs from CMC integration and the creation of new tools such as ClassNet which may provide enhanced learning experiences that are not possible with e-mail.

This leads into the second design paper, "ClassNet: Managing the Virtual Classroom", which explains in detail the nature of ClassNet. This paper begins by discussing the arising problem of virtual classroom management and introduces ClassNet as a plausible solution to that problem. Then, a description of ClassNet's use is given from both an instructor's and a student's perspective, and the concepts of assignments and assignment questions are discussed. In closing, the paper provides concrete examples of ClassNet's use in various subject domains, presents a brief vision of possibilities in preservice teacher education, and summarizes ClassNet's features and future developmental prospects.

The third paper, "Computer-Mediated Communication and Computer Simulations: A Pedagogic Synergy in Preservice Teacher Education?", presents a qualitative evaluation of a ClassNet feature. This feature manifests aspects of ClassNet's envisioned possibilities which were given in the previous two papers: It supports an online partnership in which preservice teachers can analyze and guide elementary or secondary students' interactions with computer simulations. In this particular study, 3 preservice teachers guided the discoveries of 4 distant eighth graders working with a mathematics graphing simulation. The paper describes this
experience, presents research pertinent to the study, and discusses the evaluation outcomes. The paper concludes by considering the feasibility of using this particular ClassNet feature in preservice teacher education and provides directions for future research.

Overall, the strength of this dissertation lies in the contribution of each individual paper as well as the collective contribution of all three. The first paper provides an analysis of needs that must be considered in a relatively new and growing area of research in preservice teacher education. Further, it goes beyond a discussion of the needs by contributing a vision of new learning situations which may not be perceived by non-software developers. The strength of the second paper lies in the product it represents. ClassNet has already supported the implementation and exploration of online classrooms by many educators. It also continues to support contributions to the educational body of knowledge by permitting new learning experiences and facilitating research on those experiences. The third paper's strengths stem from the creation and evaluation of a unique learning experience and the focus on preservice teacher learning resulting from that experience. It also sheds light on how that experience may support preservice teacher development and the self-efficacy of teachers encountering mathematics reform (Smith, 1996). Finally, as a collective whole, the papers provide a vision of how new developments in CMC can support the learning of preservice teachers.
References


COMPUTER-MEDIATED COMMUNICATION IN PRESERVICE TEACHER EDUCATION: SURVEYING RESEARCH, IDENTIFYING PROBLEMS, AND CONSIDERING NEEDS

A paper to be submitted to the
Journal of Computing in Teacher Education

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Abstract

Computer-mediated communication (CMC) is influencing preservice teacher education in numerous ways. Tools such as e-mail and conferencing software support extension of traditional course discussions, reduction of student teacher isolation, and creation of new partnerships with elementary or secondary students. Yet, new problems and needs have arisen from this utilization. Some require the enhancement of current CMC technologies or the creation of new technologies, while others may be independent of CMC and its use in preservice teacher education.

Subsequently, this paper provides an overview of CMC in preservice teacher education and documents emerging problems and arising needs. It then calls for the creation and exploration of new CMC technologies that nurture the learning of preservice teachers and concludes by discussing a possible support tool.

Introduction

Computer-mediated communication (CMC), a merger of computers and communication technology, is transforming the nature of education (Riel & Harasim, 1994, p. 91). CMC not only allows classrooms to transcend geographic boundaries but also lifts constraints of scheduled meeting times. Further, many educators believe that well-designed CMC activities will result in valuable learner-centered experiences (e.g. Berenfeld, 1996; Jonassen, Davidson, Collins,
Campbell, & Bannan-Haag, 1995; Stout & Thompson, 1995). As a result, the value of CMC in extending and enriching education is currently being explored.

Preservice teacher educators are showing substantial interest in investigating the value of CMC. Support tools such as e-mail, listservs, Web browsers, and Web servers easily facilitate communication among teachers, students, and researchers at all institutional levels. New classroom partnerships between schools and universities are arising, and exciting educational activities are being created. Many educators are enthusiastic about the potential of CMC (Maddux, 1994) and preservice educators in particular are calling for continued integration and exploration of its pedagogic impact (e.g. Poole, 1996a; Russet, 1995; Sumrall & Sumrall, 1995).

Nevertheless, emerging needs often accompany the integration of new and promising technologies. Addressing these needs is an important task as it drives future technology development, integration, and research. Subsequently, the primary purpose of this paper is to explore the integration of CMC into preservice teacher education and to identify and address perceived needs. In meeting this goal, a description of CMC and a categorization of its utilization in preservice teacher education is provided. Then, after reviewing uses and outcomes of CMC within these categories, problems are identified and needs are assessed. The paper concludes by discussing an evolving tool that helps meet these needs and calls for similar tools to be developed.

CMC Description and Categorization

Barker (1994) concisely describes CMC as a "telecommunication technology that employs the computer as an 'intermediary' to facilitate communications" (p. 158). An important feature of this technology is the capability to communicate either synchronously or asynchronously (Jonassen, 1996). In general, while synchronous communication occurs in real-
time between two or more individuals, asynchronous communication allows a period of unspecified latency. This latency supports both convenience and learning: Individuals are given the time they need to read, reflect upon, and formulate a response to previously received messages (Harasim, Hiltz, Teles, & Turoff, 1995, p. 4).

Meanwhile, CMC is supported by a variety of tools and holds promising pedagogic potential. For example, individuals may use IRC (Internet Relay Chat) to collaborate synchronously, e-mail to collaborate asynchronously, or World Wide Web servers to post information internationally. Tools such as these allow for the creation of profitable activities within the classroom. Berenfeld (1996) provides a classification of these activities:

- Tele-access -- Students access and retrieve information from remote sources;
- Virtual Publishing -- Students post material for online access;
- Tele-presence -- Students experience events at remote sites;
- Tele-mentoring -- Students are mentored by online experts; and
- Tele-sharing -- Students collaborate and cooperate across classrooms.

Further, Berenfeld believes the learning potential of these activities increases in ascending order from Tele-access to Tele-sharing. Other similar classifications do exist (e.g. Harasim & Hiltz, 1994), but like Berenfeld's, these are generally based upon user collaboration and the sharing of information resources.

Collis (1995) has additionally categorized the use of CMC in preservice teacher education. While inferring the value of this utilization, she writes that CMC is

- extending and enriching the traditional course environment in the initial teacher education institute;
- extending and enriching the communication and contact between student teacher, supervisor, and sponsoring teacher in the school; and
• bringing new sorts of partnerships in the initial teacher education situation. (p. 121)

These categories provide an organizational scheme for the following review of CMC in preservice teacher education. This review is not intended to be exhaustive but rather is to provide an overview of CMC use and associated educational outcomes. As a convention, the remainder of this paper will associate 'students' with preservice teachers and 'pupils' with elementary or secondary students. For example, students may practice guiding the problem solving of fifth-grade pupils.

CMC Use in Preservice Teacher Education: Evidence of Promise

Extending and Enriching the Traditional Course Environment

Enhancing the traditional classroom is an immediate means of integrating CMC into preservice education. In this approach, information access, information publishing, and classroom collaboration are three common uses of CMC to support learning.

Poole and Simonson (1995) and Russet (1995) designed tasks that prompted preservice teachers to access and utilize Internet data. Poole's students solved problems by retrieving thematic information (e.g. earthquake data) and mathematically manipulating that information to arrive at proposed solutions. One of Russet's tasks involved searching for information in remote databases and designing curriculum activities which made use of that information. Both Poole's and Russet's activities were intended to be meaningful and thought provoking. Further, students benefited by learning how to use Internet navigational tools (e.g. FTP, gopher, and TELNET) and thinking about the pedagogic potential of those tools.

Another emerging activity is World Wide Web publishing. Slough and McGrew-Zoubi's (1996) preservice teachers searched for children's literature books that introduced scientific concepts. They then wrote annotated HTML bibliographies which were eventually stored in a
Web-searchable database. The preservice teachers enjoyed the activity as they became Web contributors instead of merely Web users. A similar positive attitude was also held by Francis-Pelton and Pelton's (1996) students who created home pages of personally meaningful educational links. Meanwhile, Larson, Kinzie, McNerney, Kent, Herbert, and Becker (1996) employed a somewhat different approach: They published case-based teaching events on the Web. Preservice and inservice teachers accessed and read these cases, thought about the issues involved, and then posted their suggestions (which were automatically e-mailed to a special account). A formative evaluation showed that a team approach to case analysis works best, and the resulting in-depth team discussions promoted reflective thinking.

Finally, CMC is being used to support classroom collaboration. This collaboration generally occurs among class members and is facilitated by e-mail, listservs, and computer conferencing software. For example, Harrington and Quinn-Leering (1996) used conferencing software to support moral discourse among preservice teachers. They reported that computer conferencing provides students with opportunities to reflect upon their own knowledge and to construct meaning within a community of individuals (p. 63). Additionally, Russet (1995) and Wolff and McMullen (1995) utilized e-mail to read and respond to student journal entries. In particular, Wolff and McMullen feel that electronic journals support student reflection better than paper and pencil journals: Instructors and students can easily engage in an asynchronous dialogue about individual journal entries.

Extending and Enriching Communication During Student Teaching

CMC also enhances communication among university faculty members, university supervisors, student teachers, and cooperating teachers. The goal of this communication is to bridge the gap between the university and its student teachers stationed in remote classroom
settings. In meeting this goal, some universities furnish student teachers with computers (e.g.
Casey, 1994; Souviney, Saferstein, & Chambers, 1995), while others might install modems and
communication software in the participating schools (e.g. Yan, Anderson, & Nelson, 1994). Thus,
student teachers are provided with immediate e-mail access to suggestions, support, and feedback
from connected peers and faculty.

Two important cognitive and affective outcomes result from this use. Schlagal, Trathen,
and Blanton's (1996) study showed that e-mail collaboration between students and professors
"[revealed] the joint construction of meaning as [they engaged] in public discussion over issues of
teaching, application, and knowledge" (p. 181). Other authors also wrote that e-mail facilitated
reflective thinking and that student teachers obtained a deeper understanding of teaching through
its use (e.g. Hoover, 1994; Yan, Anderson, & Nelson, 1994). Additionally, even though e-mail
can be an impersonal medium (Thomas, Clift, & Sugimoto, 1996), it nonetheless provides student
teachers with immediate emotional support from peers and supervisors (Casey & Vogt, 1994;
Hoover, 1994). This support is needed to lessen the frustrations and anxieties that student teachers
often experience.

Building New Partnerships

Finally, CMC is being used to build new partnerships in preservice teacher education.
These partnerships, which connect individuals from different institutions, provide particularly
powerful learning experiences (Collis, 1994). Further, Berenfeld (1996) writes that collaboration
across classrooms "is one of the most sophisticated deployments of classroom
telecommunications" (p. 80). These new partnerships generally consist of collaboration between
preservice teachers and other preservice teachers, inservice teachers, or elementary and secondary
pupils.
Both Campbell and Yong (1996) and Sumrall and Sumrall (1995) investigated partnerships between classes of preservice teachers at distant universities. In Campbell and Young's investigation, two remote preservice classes used a common reflector list to post and respond to case-based lesson plans. The authors noted that preservice teachers refined their knowledge of teaching and learning through this activity. However, they believed this was due to the case-based nature of the project rather than to the scant collaboration that did occur. Meanwhile, Sumrall and Sumrall studied the pairing of preservice teachers from two remote classes. These pairs completed small tasks in which group members shared personal information and pedagogical information concerning elementary science methods. Despite difficulties arising from incorporating e-mail into the curriculum, outcomes revealed that preservice teachers held a positive overall attitude about the experience.

Norton and Sprague's study (1996) also included inservice teachers. Here, inservice teachers were paired with inservice and/or preservice teachers from a remote university. A peer group consisted of paired inservice teachers while a mentor/mentee group consisted of paired inservice and preservice teachers. After receiving instruction in telecommunications and curricular use of databases at their respective universities, each pair collaboratively designed a lesson plan that involved database integration. Results of their study revealed that preservice teachers became significantly more positive about the educational use of telecommunications; while inservice teachers' perceptions of telecommunications use remained positive throughout the study. Additionally, there was no difference in lesson plan quality between the peer or mentor/mentee pairs.

Moreover, an increasing number of investigators are exploring partnerships between preservice teachers and elementary or secondary pupils. Day (1995) and Poole (1996a, 1996b) investigated problem solving experiences between preservice teachers and classroom pupils.
Here, the preservice teachers gained experience by learning about the pupils' approaches to problem solving, guiding pupils in problem solving, and selecting problems appropriate for the age and ability level of the pupils. In another study, Allen (1997) investigated e-mail collaboration between preservice teachers and eighth-grade pupils. The content of this collaboration included personal discourse and discussion about reading, writing, or additional class work of the eighth graders. Results of the study showed that preservice teachers valued the activity, and they perceived themselves as more capable users of technology and more knowledgeable of middle school pupils’ interests and abilities in reading and writing.

Problems and Needs

Although the research that explores CMC in teacher education has been largely informal and possibly somewhat tainted by the effect of novelty (Clark, 1983), the research presented above and elsewhere does provide evidence of learning and positive student attitudes. This has occurred despite many difficulties and problems encountered during CMC integration. These problems lie within two broadly and loosely defined areas: Those problems that may dissipate with the improvement of existing CMC technology and those that may not.

Problems that may Dissipate with Improvement of Existing CMC Technology

Certain difficulties should diminish with the development of faster, more reliable, and less expensive equipment. One common problem is network access (e.g. Gunn, 1995; Makurat 1995; Souviney, Saferstein, & Chambers, 1995; Stahlhut, 1994). Here, problems include busy signals, unreliable modem connections, network down times, and unavailability of phone lines in elementary or secondary schools. A second common problem encountered by students is computer access. (e.g. Casey, 1994; Casey & Vogt, 1994; Russet, 1995; Smith, 1996; Sumrall &
Sumrall, 1995). In this case, ongoing difficulties not only occur at post-secondary levels when the
supply of portable computers does not meet the demand of student teachers but also at all
institutional levels when student access to computer labs is limited or perhaps inconvenient.
Nevertheless, these difficulties may soon lessen at the university level with increased student
ownership of computers (Casey, 1994; Sumrall & Sumrall, 1995). Access difficulties may
eventually subside at the elementary and secondary levels as well, but factors such as
socioeconomic impact will need consideration.

Problems that may Persist even with Improvement of Existing CMC Technology

Other problems mentioned in the literature may not be affected by the improvement of
existing technology. These require a deeper consideration of the uses, limitations, and
investigation of current CMC technology in preservice teacher education and may require the
creation of new technology.

Information management difficulties.

Preservice teachers in many studies experienced the impact of information overload
resulting from an overwhelming number of incoming e-mail messages (e.g. Francis-Pelton &
Pelton, 1996; Hoover, 1994). Campbell and Yong (1996) reported that students learned how to
create e-mail folders to manage the volume of information. However, this solution does not
negate the impending problem of disk quota limitations. This problem was also inferred by
Francis-Pelton and Pelton whose preservice teachers identified the savings of disk space as a
newsgroup benefit: Newsgroup messages are stored on separate file servers and thus do not
require users’ disk space. Additionally, information overload may be due to the almost exclusive
use of e-mail in teacher education (Greene, Robbins, Riley, Barnes, 1995). Because one e-mail
channel is often used for a multiplicity of tasks (e.g. class discussion, assignment distribution and collection, course announcements), the amount of information coming into one e-mail address may be overwhelming not only to students but especially to instructors.

Another problem is the management of information between institutional partnerships. Gunn (1995) wrote the following about her study that connected preservice teachers with a high school in Texas:

This project became cumbersome for the teacher facilitator in Texas—he was using one computer in the media center with his personal user ID, so in most cases, he had to download and print each message, distribute them to the 50 student and teacher participants, and then find time for his students to write messages back. (p. 597)

The problem is that elementary and secondary pupils do not have personal e-mail addresses at their schools like their university counterparts. This problem may or may not resolve itself in the near future. However, even if resolved, one may still encounter the nuisance of remembering correct e-mail addresses (e.g. Campbell & Yong, 1996; Poole & Simonson, 1995) or in managing the volume of exchanged information.

Tool limitations.

Other concerns involve the affective and cognitive limitations of CMC tools — especially e-mail. Some student teachers are dissatisfied with the impersonal nature of e-mail (e.g. Thomas, Clift, & Sugimoto, 1996) even though student teaching is a time when much emotional support is needed. Additionally, although e-mail may easily capture products of learning, it does not necessarily capture the process of learning. This is an important problem as attempting to understand one's learning and thinking processes is essential to constructivist theory (Bednar, Cunningham, Duffy, & Perry, 1992; Confrey, 1991). Poole (1996a, 1996b), attempted to capture
the process of problem solving by instructing connected elementary pupils to communicate both solutions and problem solving processes by e-mail. However, difficulties arose when the elementary pupils had trouble performing this task:

Without a solid understanding of the process used by the elementary students, the preservice teachers did not know how to respond to correct or incorrect responses. They could only reply to the correctness of a response rather than providing more detailed feedback that might help the elementary students develop better problem solving skills. (1996b, p. 159)

Here, the need to understand and visualize the pupils' problem solving processes was vital to promote future learning. E-mail did not capture this process.

Further, one must consider the advice of Berenfeld (1996). He calls educators to go beyond e-mail: "E-mail hardly qualifies as advanced telecommunications. At the core of advanced connectivity lies access to the Internet's sophisticated capabilities" (p. 76). Although he believes that e-mail supports successful and valuable learning experiences, he essentially requests the continued exploration of new technological possibilities. These, in turn, may lay the support framework for new and more powerful learning experiences which are yet unrealized.

Unclear learning results and other difficulties.

Another problem is determination of learning outcomes in CMC studies. Although research indicates that most preservice teachers hold positive attitudes about the use of CMC/telecommunications, learning outcomes are not always evident. Davis (1994) states, "There has been relatively little hard research into the benefits of electronic communication" (p. 644). Collis (1993) believes that evaluation of CMC effectiveness is apparently difficult and most existing evaluations do not examine learning. Moreover, studies exploring the learning of
connected elementary or secondary pupils in school-university partnerships are rare or perhaps nonexistent. Thus, although evidence of learning exists (e.g. Harrington & Quinn-Leering, 1996; Poole, 1996b; Schlagal, Trathen, and Blanton, 1996), additional exploration and communication of learning outcomes is necessary.

Moreover, there are difficulties which are not necessarily linked to the use of CMC in preservice teacher education. One example is the scarcity of preservice teacher time needed for collaboration or reflection (e.g. Yan, Anderson, & Nelson, 1994). Another example is the lack of collaboration due to a fear of communicating something "wrong" (e.g. Campbell & Yong, 1996). This problem is deeply entrenched in the objectivist roots of education. Other problems may include fears of technology, the inability to include CMC activities in content-packed courses, or the need to restructure CMC activities (e.g. Anderson, 1995; Sumrall & Sumrall, 1996). In essence, these problems are often related to teaching demands, activity design, student characteristics, or philosophical underpinnings.

Basic Needs

In light of these problems, the challenging ones are those that may persist even with the improvement of existing technology. This presents at least two basic needs: The need to explore new CMC technologies that facilitate and enhance the learning of preservice teachers and the need to explore the learning that results from these or already existing technologies. These two needs do not constitute a comprehensive list but are considered essential as they both involve learning.

In concurrence with Berenfeld (1996), the first need requires going beyond e-mail to create and investigate the possibilities of new technologies. These technologies may provide enriching learning experiences that are not possible with e-mail. For example, with the ongoing
development of the World Wide Web and Web-based programming technologies (e.g. Java), the potential to create new and powerful online learning environments is strong. The Web is now more than an area to access and post information: It is a place to interactively communicate and construct knowledge. However, the realization and creation of these new learning environments may only come from stronger alliances with departments such as computer science (Sumrall & Sumrall, 1996).

A second need is to evaluate and communicate the learning that results from existing or newly created CMC tools and environments. If enriching and extending the learning and knowledge of preservice teachers is the ultimate goal, than the reaching of that goal must be evaluated. Due to the complex nature of CMC learning environments (Davis, 1994), intense qualitative evaluations of the process and product of preservice teacher learning are likely necessary.

Striving to Address the Needs: An Example

In meeting these needs, a new Web-based classroom management tool (http://classnet.cc.iastate.edu) developed at Iowa State University, is being extended and evaluated in teacher education. This tool, known as ClassNet, is designed to handle administrative tasks in virtual classrooms (Van Gorp & Boysen, 1997). However, due to the general and ongoing design of this tool, new research and learning possibilities for preservice teacher education are being realized. Although ClassNet is an immediate aid to the information management problem occurring in preservice teacher classrooms (e.g. information overload, disk quota allocation), it more importantly provides potential for creating new and unique learning experiences.
ClassNet and Classroom Management

ClassNet's primary purpose is to manage information associated with global Internet classes. Because an increasing number of educators are using the Internet to deliver entire courses or to create enriching course activities, generalized Web tools such as ClassNet are being developed to handle emerging online management tasks. These tasks (e.g., assignment submission, gradebook management, and intra-class communication) are simply impractical or impossible to handle with e-mail alone or are difficult to manage by using a menagerie of Internet tools that do not centralize information.

To meet this information management need, ClassNet was designed to support a variety of online tasks for instructors and students. For example, by utilizing ClassNet's Web interface, students may register for classes, complete assignments, retrieve course grades, and participate in discussions; whereas instructors may manage assignments, control class enrollment, communicate with students, and monitor student progress. Further, ClassNet supports the management of virtual partnerships between preservice teachers and distant elementary or secondary classrooms: An online classroom can be created in which the preservice teachers are the actual teachers and the elementary or secondary pupils are the actual students.

ClassNet and Teacher Education

When considering ClassNet's potential in teacher education, several learning possibilities emerge. Some of these possibilities are currently being implemented and evaluated, while others are untested opportunities that hold inviting pedagogic promise.

For example, one inservice teacher in counselor education recently used ClassNet to create a simple Web assignment consisting only of a story and questions about the story. For the duration of a week, she and each of her remote high school pupil-clients privately discussed this
story through HTML textboxes contained in the assignment. The counselor educator is currently
evaluating her experience but feels that an entire counselor education course should be
constructed around this activity. The authentic problems presented by real students were
meaningful, and asynchronous communication presented opportunities to think about and discuss
counseling approaches with professors and peers while constructing optimal guidance to send.
The benefits reaped from this experience were mutual: She not only learned about counseling and
pupil needs, but the pupils also profited from her counseling support. Incidentally, because this
activity was supported by ClassNet, there was no need for e-mail addresses, no management
concerns, and no disk quota worries — the focus was on counseling and learning.

Although this activity in counselor education is a simple use of ClassNet, the benefits for
both the inservice teacher and her pupil-clients were evident. Further, while reflecting upon
ClassNet's potential, future learning experiences and research studies are immediately envisioned:

Elementary preservice teachers enrolled in a language arts methods course constructed an
assignment with a picture and a textbox. A joint construction of a story between individual
preservice teachers and remote elementary pupils followed. After the stories were
completed, the teachers presented the stories in class and discussed what they had learned.

Groups of preservice teachers from a multicultural education course constructed Web
surveys for pupils in diverse cultural and geographic locations. Their surveys consisted of
a variety of text and multimedia items. Survey results were presented in class and a
discussion tying survey results with theory ensued.

Preservice teachers enrolled in an elementary mathematics methods course used an
assignment containing an embedded computer simulation. Through the use of this
simulation, connected eighth graders explored the graphing of linear equations and made hypotheses about the effects of adjusting linear coefficients. Meanwhile, the preservice teachers played back the pupil interactions with the simulation and analyzed the eighth graders’ thinking processes. After discussing the eighth graders’ thinking, the preservice teachers provided guidance for further simulation exploration.

Preservice teachers enrolled in a general education course used an online computer simulation to explore aspects of classroom discipline. Their interactions and decisions with the simulation were recorded and analyzed by the course instructor. In the next class meeting, the simulation was discussed as well as the decisions that were made. These envisioned opportunities show that ClassNet may be used not only to create new partnerships but also to enhance the traditional classroom. Here, the power of ClassNet resides in the facilitation of new learning experiences that are simply not feasible or possible with tools such as e-mail. In turn, research is needed to evaluate the learning which these opportunities may provide.

Nevertheless, because of ClassNet’s formative nature, it is continually being upgraded and evaluated. Some tasks such as assignment creation and distribution are relatively simple to accomplish, while other tasks such as simulation exploration require programmers to initially create the computer simulation. Additionally, because ClassNet was originally developed to meet management needs of virtual classrooms, its design is not tailored to teacher education. Yet, its current general design does provide support in this area, and its future design may target the auxiliary needs of teacher education as well.
Conclusion

The integration and evaluation of CMC into preservice teacher education is a relatively new and growing area of research. Although this research is not without problems, the potential of CMC as a learning tool appears to be bright. However, this potential may only be realized through a deeper examination of learning and the creation of new support tools.

ClassNet is only one example of an evolving tool that may be used to support new and enriching learning experiences. By utilizing the Web's multimedia capabilities, ClassNet supports not only the management of online information but also the creation of learning activities within preservice classrooms and between preservice classrooms and other institutions. However, its value in supporting the education of teachers must continue to be investigated. Other possible support tools must also continue to be envisioned, created, and evaluated; but this may require the nurturing of yet another partnership — between the computer scientist and the teacher educator. Nevertheless, it is hoped that experiences resulting from these tools will contribute to the development of future teachers.

References


Annual, 1995 (pp. 142-145). Charlottesville, VA: Association for the Advancement of Computing in Education.


CLASSNET: MANAGING THE VIRTUAL CLASSROOM

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Abstract

Education continues to move on-line through the World Wide Web. Classrooms of students and teachers are no longer restricted by time or distance. ClassNet (http://classnet.cc.iastate.edu/) is a tool which manages these virtual classrooms: it automates many of the administrative tasks associated with global Internet classes. Through a simple interface of Web forms, students may perform activities such as class registration, assignment submission, and grade retrieval. Meanwhile, instructors may perform tasks such as managing assignments, controlling class enrollment, communicating with students, and monitoring student progress. This article highlights features of ClassNet's design and functionality and provides examples of its use.

Introduction

Virtual classrooms, virtual degrees, and virtual universities are actually explicit realities in today's educational community. Barker (1994) notes that we are now educating geographically diverse populations and that "virtual [classrooms] will become as commonplace in higher education as the chalkboard once was" (p. 159). One only needs to visit either the World Lecture Hall at the University of Texas at Austin (http://www.utexas.edu/world/instruction/index.html) or the Open University in England (http://www.open.ac.uk/) to find concrete examples of this educational phenomenon (Shotsberger, 1996). Further, well designed activities via the Web can offer students a valuable learner-centered education (Stout & Thompson, 1995).
However, how are these distance-oriented classrooms managed? Who or what handles details such as the registration, grades, assignments, portfolios, and tests? Some have used e-mail for handling a few of these details (Pitt, 1996; Poling, 1994; Wei He & Knapp, 1995). Others have programmers developing CGI-scripts specifically for their classes (Dix, Allendoerfer, Jones, Lacey, & Laurenzi, 1995). These scripts handle the student information (originating from a browser interface) and may or may not store the information centrally. Unfortunately, e-mail presents disk space and organizational problems (Wei He & Knapp, 1995), not all instructors involved in distance education have access to a programmer, and some CGI-scripts already developed are too specific for use across a wide array of classes.

ClassNet (http://classnet.cc.iastate.edu/) is a general solution to this problem. Its purpose is to bring automated administrative functionality to global Internet classes. Classrooms and their management details are handled by a tool that organizes the diverse information needed to administer these classes. Students and teachers interact with this tool through a simple Web interface and thus only need access to a browser of their choice. Although ClassNet's purpose is not unique (e.g. http://west.ucd.ie/; http://homebrew1.cs.ubc.ca/webct/), many aspects of its design and functionality are.

ClassNet Description -- A User's Perspective

ClassNet is a collection of Perl5 CGI-scripts running underneath a UNIX HTTP server (see Figure 1). Users interact with ClassNet through simple HTML forms; ClassNet, in turn, acts as the gateway between a database of registered classes and the users. Users are either instructors or students.
Class Creation and Enrollment

Class creation is accomplished by filling out a request form linked to ClassNet's main menu (see Figure 2). Here, instructors may control student registration by specifying whether class enrollment is open, approved, or closed. If open, students are automatically added to a class when requesting enrollment. If approved, student enrollment requests are first approved by the instructor before those students are added to the class. If closed, students are not allowed to request enrollment; rather, any student additions are performed manually by the instructor.

Because anyone may register for a non-closed class, the instructor approval feature provides a way to filter out any spurious enrollment requests. After the instructor submits the class request form, she or he is notified by e-mail of class creation. The instructor then becomes the owner of the new class.

Users become members of a created class through a variety of means. Students may self-enroll by completing an enrollment form linked to ClassNet's main menu. Also, class owners may enroll additional instructors with assigned privileges. Current privileges are managing students, managing assignments, and proctoring exams. Finally, a list of students or instructors may be automatically enrolled by uploading a Web-readable file.

Starting a Session

All class members must login from ClassNet's main menu. After a class name is selected and the "Login" button is pressed, the user is asked for his/her name and password. Subsequently, an instructor or student menu is presented if the user is verified as a valid instructor or student member of the selected class.
The Instructor's Perspective

The instructor menu (see Figure 3) provides the interface to a myriad of classroom management tasks. Each menu button typically provides a link to another lower-level menu designed to support related management responsibilities. The following instructor tasks are supported by these lower-level menus:

Members
- edit or list class member information
- add or delete class members

Assignments
- add, edit, or delete assignments
- receive an e-mailed copy of an assignment

Gradebook
- view scores for students and assignments
- view summary statistics for an assignment
- re-grade student assignments
- receive e-mailed raw data assignment answers for selected students
- view, edit, and grade individual student assignments
- add and delete assignments for selected students

Class Options
- open or close class enrollment
- approve or disapprove enrollment requests
- set date for class expiration

Personal Data
- change personal e-mail address or ClassNet password
The assignment and gradebook menus are responsible for assignment management. The concept of an assignment and how it is managed will be discussed in a separate section below.

The remaining instructor menu buttons support communication. The instructor may e-mail class members, discuss topics with members via a discussion forum, change characteristics of that forum, and chat with students interactively. Thus, means for both synchronous and asynchronous communication are provided.

The Student's Perspective

Students may perform a variety of confidential tasks through the student menu (see Figure 4). A student may select an unfinished assignment and choose to complete it. Consequently, an assignment form is sent to the student, and the student resubmits the form upon completion. If the instructor permits, students may also select a completed assignment and view their answers and the answer key. Additionally, students may view a summary of their assignment scores or change their password and e-mail address.

Asynchronous and synchronous communication privileges are similar to the instructor's. Students may e-mail other class members, join in a classroom discussion forum, and interactively chat with other class members. Unlike instructors, students may not edit characteristics of a discussion forum.

Assignments

Assignments are HTML forms (e.g. see Figure 5) created by the instructor and stored in ClassNet’s database. A ClassNet assignment editor helps instructors build various types of assignment forms. Through the editor, an instructor may perform question-level activities such as adding questions, editing questions, providing answers to questions, and specifying question point totals. Instructors may also perform assignment-level activities such as specifying a due
date, making the assignment available for student completion, and permitting students to view the answer key. Knowledge of HTML is not required in the assignment construction process, although it can be advantageously used to construct assignments containing audio, video, or Java simulations.

**Assignment Types**

ClassNet is designed to support a growing list of assignment types. Due to ClassNet's underlying object-oriented code, new assignment types can be added easily. Currently, three assignment types are supported:

- **Test** is a series of multiple-choice, short-answer, and essay questions. Questions can be randomly generated, or random versions of a test can be administered. When students submit their answers, the multiple-choice and short-answer questions are automatically graded. The instructor may then edit the student answers to grade and comment on the essay questions.

- **In-Class** provides the ability to record scores from paper tests or assignments which are administered outside of ClassNet. Instructors can create In-Class assignments and enter scores for students. These scores will be reported along with the other assignment types.

- **Forecast** is a Test which requests information about tomorrow's expected weather at different sites in the United States. A Forecast inherits the features of a Test and includes additional features which support its use in meteorology. Students may complete weather forecasts on a daily basis, and a current project goal is to automatically grade these forecasts for all reporting sites in the United States.

A fourth assignment type is implicitly included in this assignment list: a Survey is regarded as an ungraded Test or as a Test with zero points.
Question Types

Five question types are recognized by ClassNet: choice (one correct answer of many choices), multiple (more than one correct answer of many choices), short-answer, essay, and Likert. As mentioned previously, choice, multiple, and short-answer questions are automatically graded. Short-answer questions may have a range specified for numeric answers or judging behavior specified for string answers (e.g. enforce capitalization or spelling). Alternative short answers may be provided (e.g. ans1ans2ans3) and dynamic answers may be generated (e.g. {ANS1}). For dynamic answers, a file of name-value pairs is read and the name (e.g. ANS1) is replaced by the value before judging occurs. This provides a very general way of dealing with dynamic answers like those in weather forecasts. Essay questions are graded by the instructor through the gradebook menu. Here, the instructor may assign a score to a student’s answer and insert comments. Finally, Likert questions are actually a special type of multiple-choice question. These questions represent a scale from one extreme to another, and the achieved score for each question represents the answer chosen. The answers may also be weighted.

Organization of the ClassNet Database

ClassNet’s database is currently organized as UNIX directories and file structures. All classes are stored on a secure disk accessible only by ClassNet administrators, and backups are performed weekly. Figure 6 depicts the primary directories in a typical class layout. The bottom rows of directories (underlined) contain the files needed for class management. The member_lists directory contains class lists of instructor and student names. The instructors and students directories contain individual class member files which hold four pieces of information: first name, last name, password, and e-mail address. The requests directory contains those students requesting enrollment. A student file is moved from this directory to the students directory when an instructor approves enrollment of that particular student. The assignments directory contains
all the HTML assignments for a class. Assignment management information such as due dates, grading specifications, and answer keys are also stored in this directory. Lastly, the graded and ungraded directories contain each student's submitted graded and ungraded assignments.

Examples of ClassNet's Use

Forecasts

The meteorology department at Iowa State University has used ClassNet to manage daily weather forecasts of 250 students in a weather forecasting contest. Each student submits approximately 60 forecasts per semester. Students extract weather information from on-line products such as surface maps and satellite images and then submit forecasts for the following day. A forecast form asks students for 6 a.m. and noon temperatures, wind speed, wind direction, and precipitation, as well as explanations for their predictions. One assignment form is used for multiple assignments, and the students are bound to an explicit deadline of midnight to complete each day’s forecast.

Because meteorology’s forecast assignment consists only of multiple-choice and short-answer questions, ClassNet grades the entire student forecast automatically (If it contained essay questions, further human evaluation would be needed.). When a student submits a forecast, ClassNet stores the student answers and then grades all previously ungraded forecasts. It cannot grade the current forecast as the true answers cannot be identified until at least the next day.

Survey Research

A Ph.D. candidate at Iowa State is using ClassNet for a series of surveys. Her initial surveys consist entirely of essay questions, and her respondents subsequently answer these questions and submit the forms. ClassNet processes the forms, formats the answers, and re- routes
the answers to a specified e-mail address. Final surveys will be multiple-choice forms (Likert scale).

Using Web forms in survey research answers some disadvantages listed by Thach (1995) concerning the use of electronic mail surveys. For example, e-mailed questionnaires generally cannot guarantee anonymity because a returned questionnaire is usually accompanied by the respondent's e-mail address. Further, some users may have difficulty replying to these questionnaires: Extra instructions may be needed to help less technologically sophisticated users perform functions such as copying and pasting into a reply mode. However, forms through ClassNet can guarantee anonymity as a single fictitious name can potentially handle surveys from multiple individuals. Further, completing a survey form should alleviate the need for extra instruction on mechanics: Components such as radio buttons, checkboxes, and textboxes allow easy user input into the form.

Self-tests

Professors in geology and other disciplines are using ClassNet to administer self-tests to students. Students may complete these tests and immediately see their results. Feedback may also be provided including links to support material.

Personality Testing

A professor in psychology is using the Likert scales to administer personality testing. Students complete the test and then may immediately see their results. Currently, ClassNet support is somewhat limited since sub-scores are needed but not provided. For example, a researcher may need a single test to measure multiple respondent characteristics (e.g. attitude and anxiety). A sub-score for each characteristic must then be obtained from test items measuring that characteristic. Sub-score capability will be provided in the near future and will thus provide
researchers and respondents further means of test analysis. Meanwhile, the professor is presently using a ClassNet option to generate a mail file of raw data which can be further processed to provide these sub-scores.

Virtual Classroom Partnerships

Plans exist to further support connections between preservice teachers at Iowa State and elementary or secondary pupils. Through ClassNet, a virtual classroom is envisioned where the preservice teachers are the actual teachers and the elementary or secondary pupils are the actual students. ClassNet supports a variety of activities in this on-line partnership. For example, preservice teachers can construct Web-based problems and analyze student responses.

Features and Futures

In summary, ClassNet contains the following features:

• location, time, and device independent access
• easy classroom management integration with existing Web materials
• course-independent structure
• separation of course content from course management
• automated management helping instructors focus on teaching, not grading
• securely stored classroom management information (e.g. grades and assignments)
• centralized accessibility to organized classroom data
• immediate and private access to individual assignments and grades
• capability to edit student grades and assignments or to automatically re-grade entire class assignments
• synchronous and asynchronous communication support
• generation of randomized test questions or randomized test versions
• easy distribution and collection of surveys
• statistical analysis of individual survey and test items
• survey anonymity
• free distribution

Separating content delivery from course management is a design decision deserving special attention. By relegating content delivery to other servers, ClassNet can manage many more classes and provide better performance than a server which must do both. Classroom data for the past semester (fall, 1996) has only required 10.7 megabytes of storage space for approximately 45 classes (both national and international) and 560 students, while maintaining an acceptable level of performance.

Requests for new ClassNet features include:
• storing links to student Web page portfolios
• calculating weighted grades and permit deletion of lowest score
• storing or routing incoming data from Java simulations
• providing a class calendar
• providing a reminder file of important deadlines

Conclusion

The development of ClassNet has been an exciting and ongoing process of thinking how to improve education using the Internet. The use of the Web and CGI-scripts have allowed distance education to become much more interactive. For example, the weather forecasting contest has been extended to other elementary, secondary, and post-secondary students and classes. This was not possible without the use of a tool such as ClassNet and required no modification of ClassNet's design. Our hope is that ClassNet will aid teachers in facilitating the learning process by better managing local as well as global classrooms.
References


Figure 1. ClassNet environment.
Figure 2. ClassNet Main Menu.
Figure 3. ClassNet Instructor Menu.
Figure 4. ClassNet Student Menu.
Lesson Vincent

1) Which taxonomic category does it fit in?
   - Experiencing
   - Informing
   - Reinforcing
   - Integrating
   - Utilizing

2) Give a brief description of the lesson.

Lesson Electronics

1) Which taxonomic category does it fit in?

Figure 5. Partial example of a ClassNet assignment.
Figure 6. ClassNet directory structure.
COMPUTER-MEDIATED COMMUNICATION AND COMPUTER SIMULATIONS: A PEDAGOGIC SYNERGY IN PRESERVICE TEACHER EDUCATION?

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Abstract

Student-centered thinking and learning is essential to constructivist theory and mathematics reform; however, developing preservice teachers are rarely able to focus on their students as learners. Thus, a tool which provides additional opportunities to experience a student-centered approach was created and evaluated in preservice teacher education. This tool, comprised of computer-mediated communication and computer simulation technologies, allows teachers to analyze and guide student interactions (protocols) with Java simulations. Subsequently, its value was explored by investigating a partnership of preservice teachers and distant eighth-grade students joined by an online mathematics graphing simulation. Arising themes showed that preservice teachers had to intensely think not only about student thinking and learning, but also about mathematics and future instruction. The preservice teachers also grew as teachers and valued the opportunity to explore and guide student learning. Overall, the tool is considered feasible to use in situations where preservice teachers are closely monitored by supervising teachers, but its utilization in an entire preservice classroom is questioned. Future research is needed to investigate different participants, different settings, and different simulations. Additionally, the development and evaluation of a synchronous component is needed, and the design of additional protocol exploration activities is advocated.
Introduction

Computer simulations and computer-mediated communication (CMC) are two distinct and promising educational tools. On one hand, "One might say that simulation has come to the rescue of computer use in the classroom" (Crookal, 1988, p. 3). On the other hand, Riel and Harasim (1994) write, "Computers and communication technology are changing the nature of education" (p. 91), and many authors speak of the rich, collaborative knowledge-building experiences that CMC affords (e.g. Harasim, Hiltz, Teles, & Turoff, 1995; Jonassen, 1996). Further, these technologies best support different but valuable approaches to learning. Simulations are generally constrained environments supporting individual thinking and reflection whereas CMC is often an open environment supporting the sharing of information and the communication of ideas and diverse perspectives.

However, when considering the educational benefits of both tools, it is compelling that educators seek to integrate these technologies in complimentary ways. Thus, the purpose of this study is to investigate the effects of embedding a simulation into an online virtual classroom management system known as ClassNet (Van Gorp & Boysen, 1997). One of ClassNet's features is the capability to track and store interactions with Java simulations across the Internet. When used in teacher education, this feature allows preservice or inservice teachers to analyze and guide student interactions independently of time and space. Subsequently, the feasibility of using this feature with preservice teachers and online junior high students is explored.

The ensuing paper presents the study in four primary parts. First, this study's definition and use of CMC and computer simulations is clarified. Then, relevant literature is discussed along with questions motivating the need for creating and evaluating this new computer-mediated feature in preservice teacher education. Finally, research methodology and themes arising from
the study are described, and outcomes of the evaluation are considered in terms of feasibility and future research.

**Terminology and Usage**

Computer simulations have received a variety of definitions in the literature and consequently have been designed to support a variety of tasks. Thomas and Hooper (1991) write:

> A computer-based instructional simulation is a computer program containing a manipulatable model of a real or theoretical system. The program enables the student to change the model from a given state to a specified goal state by directing it through a number of intermediate states. Thus, the program accepts commands from the user, alters the state of the model, and when appropriate displays the new state. (p. 498)

The authors do not believe that computer simulations provide explicit feedback for user direction or error explanation: The only feedback is that which is natural to the simulation. Additional feedback or guidance would likely be left to the classroom teacher. In contrast, other authors such as Reigeluth and Schwartz (1989) speak of artificial feedback components which serve to optimize learning and motivation. Thomas and Hooper would classify these as "impure" simulations which instead resemble computer tutorials. The simulation used in this study does not employ artificial feedback and is thus characterized as a "pure" simulation.

CMC is defined by Barker (1994) as "a telecommunication technology that employs the computer as an intermediary to facilitate communications" (p. 158). CMC includes tools such as e-mail, bulletin boards, computer conferencing software, and the World Wide Web. Collis (1995) describes three primary uses of CMC in preservice teacher education:

(a) extending and enriching the traditional course environment in the initial teacher education institute;
(b) extending and enriching the communication and contact between student teacher, supervisor, and sponsoring teacher in the school; and

(c) bringing new sorts of partnerships in the initial teacher education situation. (p. 121)

Collis further believes that CMC is contributing to teacher education in many beneficial and unique ways. CMC use in this study attempts to build a new partnership in preservice teacher education.

**Motivating Theory, Research, and Concerns**

While computer simulations and CMC contributed the technological support for the study, existing theory and research provided the incentive. In particular, constructivism, mathematics reform, and preservice teacher development literature jointly indicate a need for preservice teachers to experience and practice a student-centered approach to teaching.

**Constructivism and Mathematics Reform**

According to Fosnot (1996), "Constructivism is a theory about knowledge and learning: it describes both what 'knowing' is and how one 'comes to know'" (p. ix). Coming to know requires the learner to actively construct personal meaning and understanding on the basis of experiences and alternative perspectives (Bednar, Cunningham, Duffy, & Perry, 1992). Meanwhile, knowing involves the effective functioning of a learner in a targeted discipline as well as the sufficient ability to defend and explain decisions through developed metacognitive skills (Bednar, et al., 1992). In retrospect, much of constructivist theory rests on the earlier work of Piaget and Vygotsky (Fosnot, 1996; Phillips, 1995; Cunningham, 1992; Gadainidis, 1994).

Meanwhile, constructivist principles form the basis of mathematics reform. For reformers, coming to know mathematics does not involve the traditional memorization of
algorithms or the procedural manipulation of algebraic symbols; rather, to make sense of mathematics, students must be given problem solving opportunities that involve building mathematical models, representing ideas, making conjectures, and experiencing multiple perspectives and mathematical representations (National Council of Teachers of Mathematics [NCTM], 1989; Smith, 1996). Further, knowing mathematics includes a student’s ability to solve problems, construct conjectures, defend arguments, and reflect upon one’s thinking (NCTM, 1989). Goals of this reform include fostering conceptual mathematical understanding (Schifter & Fosnot, 1993; von Glasersfield, 1991) and better preparing learners for the twenty-first century (National Research Council [NRC], 1990).

Consequently, both teachers and students must undergo a role change. Students are no longer passive information recipients but must "buy in" to the notion of controlling their own learning through the active exploration of concepts and the construction of personal understanding (Perkins, 1992). Additionally, teachers are no longer information transmitters but rather serve as guides in learning environments that support the construction of knowledge. This is especially challenging in mathematics reform where a teacher’s sense of self-efficacy is undermined: "The mathematics that teachers know best is reduced in value, substantial emphasis is given to unfamiliar content, and only the most general instructional principles are provided for teaching that content" (Smith, 1996, p. 388).

Because many mathematics preservice and inservice teachers have not experienced the mathematics learning and teaching envisioned by the reform, teacher support and development is crucial (NCTM, 1991). Teachers are products of traditional mathematics environments and "must redefine their ideas about mathematics learning and teaching" (Schifter & Simon, 1992, p. 187). To teach mathematics envisioned in the standards, teachers must directly focus on student
learning and understanding. For example, implications of orchestrating classroom discourse include:

- posing questions and tasks that elicit, engage, and challenge each student's thinking;
- listening carefully to students' ideas;
- asking students to clarify and justify their ideas orally and in writing; and
- deciding what to pursue in depth from among the ideas that students bring up during a discussion. (NCTM, 1991, p. 35)

Clearly, the focus is on student-centered learning, and developing teachers must be given opportunities to practice this type of instruction.

Preservice Teacher Development

Meanwhile, research suggests that developing preservice teachers do not initially experience concern for students or student learning. If this concern does arise, it occurs late in the preservice curriculum. Lederman and Gess-Newsome (1991) write: "Can a preservice teacher have 'real' concerns for students prior to being in a situation which actually contains 'real' students?" (p. 453). The authors believe that most genuine concerns will likely not be held until preservice teachers are faced with real students in their field-based experiences.

Other authors, when proposing and researching developmental models of preservice/novice teachers, express similar sentiments. Fuller and Brown (1975) believe that preservice teachers may pass sequentially through four stages of concern:

1) Preteaching concerns -- possess only vague notions of teaching and identify realistically with students but not with teachers.

2) Survival concerns -- concerned with class control, content mastery, and supervisor evaluations.
3) Teaching situation concerns - realize the limitations, frustrations, and demands of teaching.

4) Pupil concerns - express concerns about the academic, social, and emotional needs of students as well as the ability to relate to them individually.

In essence, preservice teacher concerns gradually move from the self to the student. Additionally, Berliner (1986, 1988) believes that automatization of procedural skills may be necessary before teachers can progress to higher levels of expertise and student concern. Kagan (1992) confirms the ideas of Berliner and Fuller and Brown. However, unlike Fuller and Brown, she proposes that teacher self-concern is an important and necessary initial stage for teacher growth rather than a presumed weakness.

**Questions and Concerns**

The documented research of preservice teacher development should invoke concern. A primary concern is that preservice teachers may have inadequate opportunities to focus on students and student learning. Kagan (1992) writes that "student teachers approach the classroom with a critical lack of knowledge about pupils" (p. 142). She believes that a novice teacher's growing knowledge of pupils must be used to challenge and reconstruct primary beliefs and images of teachers and students:

In constructing images of teachers, novices may extrapolate (albeit unconsciously) from their own experiences as learners, in essence, assuming that their pupils will possess learning styles, aptitudes, interests, and problems similar to their own. This may partially explain why novices' images of pupils are usually inaccurate. (p. 145)

Further, in a study by Hollingsworth (1989), only 5 of 14 preservice teachers reached the final stage of focusing on student learning.
Insufficient opportunities to construct knowledge of students and their learning is especially troublesome when considering constructivism and mathematics reform. The need to understand student thinking and learning is central to these movements. Further, waiting a few years for an inservice teacher's focal transition from self to student may not be adequate either. Almost half of new teachers leave the profession within the first 5 years and most of those within the first 1 or 2 years (Karge, Sandin, & Young, 1993). This latency may inhibit much student learning.

How can preservice teachers be given more opportunities to experience concern for student learning? How can preservice teachers encounter the different knowledge structures, reasoning strategies, attitudes, and moral or cultural values possessed by their potential students? Some institutions have proposed a year of internship in schools while others have proposed required practica throughout the preservice teachers' undergraduate studies (McDermott, Gormley, Rothenberg, & Hammer, 1995). Karge, Sandin, and Young (1993) write that preservice programs must be built around the developmental models: Classroom management skills must be taught first with classroom based experience included throughout the program.

However, problems are inherent in some of these proposed solutions. For example, extended field-based practica may involve more expense, more time, and more transportation concerns. Further, the need to experience culturally diverse perspectives may not be met by travelling to classrooms within a fixed mileage radius. Finally, the belief that teacher educators must linearly focus first upon classroom management skills and later upon student learning should be questioned.
Guiding Questions

The above theories, questions, and concerns provided the impetus to create an environment where student learning is the focus. Although preservice teachers must become skilled classroom managers, it is believed that computer simulations and World Wide Web technology can provide a partnership helping preservice teachers focus on the thinking of elementary or secondary students — without a prerequisite of classroom management skills. With this in mind, a tool was created and its feasibility evaluated in preservice teacher education. The following questions guided the initial evaluative study of the tool and its associated activity of analyzing student protocols:

- Does this tool support general preservice teacher development by providing opportunities to focus on student learning?
- Does this tool support the development of teacher efficacy in alignment with mathematics reform?
- Do preservice teachers see this as a valuable and authentic learning activity?
- What are the positive and negative aspects of this activity?

This evaluation focuses on "the effect of networking on individual participants" (Riel & Harasim, 1994, p. 96) as the learning of individual preservice teachers will be explored. The nature of the evaluation is both formative and qualitative.

Tool Description

The tool used is a software feature built into a virtual classroom management system known as ClassNet (Van Gorp & Boysen, 1997). ClassNet is designed to handle management details in distance or Web-based classrooms (e.g. class registration and assignment submission). Additionally, ClassNet can manage virtual partnerships between elementary, secondary, and
teacher education classrooms. For example, Web-based activities for preservice teachers may include:

- constructing multi-media assignments and questions for distant students;
- interacting with students of diverse backgrounds and ways of learning;
- allowing group discussion and analysis of student reasoning skills, beliefs, attitudes, and values;
- providing synchronous and asynchronous (n-n) dialog with classroom students; and
- analyzing student interactions with computer simulations.

The ClassNet feature supporting this last activity will be evaluated: The capability to track and store student interactions with computer simulations over the Internet. These student-simulation interactions will be termed "protocols".

The particular Java simulation designed for this study is called "Lesson Graph" (see Figure 1). Lesson Graph is a computer simulation that allows students to experiment with linear equations of the form $Ax + By = C$. In conjunction with mathematics reform, the simulation is designed to support student exploration and conjecturing about the relationship between the parameters of algebraic equations and characteristics of their graphical representations. To use the simulation, students enter numbers for the coefficients and instruct the simulation to plot the line. By selectively changing the coefficients and observing the results, students can gain and articulate an understanding of concepts such as y-intercept and slope. Further, students enter posed conjectures into a conjecture box by clicking on "Post Idea". These conjectures and entered numeric coefficients leading to the conjectures are automatically routed to and stored in ClassNet. Students may also press "Reply to Teacher Notes" to read and respond to guidance entered by their assigned teachers.
Meanwhile, teachers view a slightly different version of Lesson Graph (see Figure 2). Their version allows retrieval of protocol data for a particular date and student. Teachers replay the individual student protocols by stepping through the entered coefficients, graphed lines, and posed conjectures. All data is stored and replayed sequentially: thus permitting teachers to step through the process of student thinking. After thinking about and discussing each student's thinking, teachers may then enter guidance for each individual student by pressing "Send Notes to Student". The student will use that guidance for support in his/her next session.

ClassNet manages the distribution of each Lesson Graph version by differentiating between individual teachers and students. It also provides for the collection of student protocols, the capability to replay those protocols, and the storage of teacher-student communication. Password use guarantees privacy of all teacher-student sessions.

Methodology

A qualitative approach was chosen for the research study. This approach was taken primarily because I was seeking to understand the preservice teachers' learning in addition to the value they attributed to protocol analysis. The researcher as key research instrument, the goal of understanding the preservice teachers' perspectives, inductive analysis of data, and a focus on the process of teaching and learning all contributed to the qualitative nature of the study (Bogdan & Biklen, 1992). The understanding constructed from this approach revealed the feasibility of using protocol analysis with preservice teachers.
Pilot Study

A sequence of meetings and protocol sessions served to organize the investigation of protocol analysis. Initially, a pilot study was conducted to test the software, guide the organization of the upcoming study, and give the teacher group an opportunity to practice.

Participants

To find teacher and student participants, the researchers (major professor and myself) described the study to four elementary education classes at Iowa State University. Two of these classes were sections from a mathematics methods course and the other two were sections from an introductory mathematics content course. Subsequently, 1 male and 2 female preservice teachers from the content course volunteered for the teacher group: This low number was likely due to the time commitment needed from the teacher group and the secondary nature of linear equations. None of these preservice teachers had yet taken any methods courses. Brad and Amy (pseudonyms) had taken algebra I, algebra II, and geometry in high school. Brad previously disliked mathematics but would now characterize his attitude as indifferent. Amy, on the other hand, "loved" mathematics and science. Both had minimal teaching experience: Brad was involved in one summer outdoor education camp, and Amy had tutored kindergartners for 9 weeks while in high school. Terry (pseudonym) had been out of high school for approximately 20 years. She could not specifically remember her previous mathematics courses taken but already possessed an undergraduate degree in finance. She was indifferent toward mathematics and her only previous teaching experience was aiding in her fifth-grade daughter's class. All 3 teachers were given one undergraduate credit for participating.

From the two methods classes, 2 pairs (3 females and 1 male) of senior elementary education majors volunteered to be students in the pilot study. For these preservice teachers, the
pilot study served as a course project and provided an opportunity to learn more about mathematical conjecturing, pedagogic uses of technology, and relationships between linear coefficients and graphed lines. All 4 students had worked with $y = mx + b$ but not with $Ax + By = C$.

**Organization.**

Each student and teacher group received an initial orientation conducted by the researchers. In both meetings, NCTM standards for mathematics reform were discussed in addition to the pilot study's purpose. Also, both groups were introduced (or reintroduced) to $Ax + By = C$, the construction of $(x,y)$ tables, and the plotting of $(x,y)$ points. The student pairs were given two distinct goals:

1) Find as many relationships as possible between the A, B, and C coefficients and the graphed lines.
2) Determine how to go directly from the equation to the graphed line without making a table of points.

Meanwhile, the teacher group discussed how to constructively support the student pairs in achieving these goals.

The student pairs worked with Lesson Graph on alternate days for a one week period. In between these days, teachers replayed the student protocols, discussed the student thinking, and provided guidance for the next student session. Amy worked individually with one student pair while Brad and Terry worked together with the other pair. The researchers served as participant observers during the teacher sessions. I also observed the student pairs during their third and final session. Upon pilot study completion, the student group completed a simple evaluation consisting of four open-ended essay questions, and the teachers participated in a semi-structured group interview with the researchers.
A number of important findings arose that not only guided the design of the software and the upcoming study but also provided a glimpse of the value of protocol analysis. First, the pilot students also needed to replay their previous protocol sessions. Thus, ClassNet was given this capability immediately after pilot study completion. Second, both teachers and students believed that working with Lesson Graph on consecutive days would be better than on alternate days: They had difficulty remembering where they had stopped in previous sessions. Third, the teachers and students began seeing the power of using mathematical strategies. Strategy use will be described further in the thematic discussion below. Finally, both groups were very positive about the analysis of student protocols as a pedagogical tool, and the teachers were eagerly anticipating their collaboration with the eighth graders.

Research Study

Participants.

The teacher participants were the same as in the pilot study, but the student participants were found by contacting the eighth-grade mathematics teacher in a small junior high school located 75 miles from Iowa State. This school was chosen because I was familiar with the school and its faculty. After the teacher explained the study to his pre-algebra students, 4 eighth-grade boys volunteered. The teacher described two of them as top achievers in the class while the other two were described as average achievers. Both average achievers had high ability but needed to be motivated to show it. In particular, one average achiever was described as being "so bright that he is bored." All 4 students had experience graphing linear equations by creating tables of (x,f(x)) points. However, none had seen the equation Ax + By = C or worked with slope and y-intercept. Two student pairs were formed — each containing a top and average achiever.
Once again, the researchers held an initial orientation meeting with the teacher group. The primary purpose was to discuss learning outcomes from Lesson Graph. These outcomes were drawn from the previous pilot study and from earlier work with a non-networked version of Lesson Graph (e.g., Thomas & Thomas, 1997). These experiences have shown Lesson Graph to encourage student thinking and learning at three levels: mathematics content (e.g., Changing only ‘C’ produces parallel lines.), domain specific metacognitive skills (e.g., Use of zero simplifies the equation and the graph.), and general metacognitive skills (e.g., A discovery should be generalized if possible.). Another purpose of the meeting was to assign student pairs to the teachers. Once again, Amy volunteered to work with one pair, while Terry and Brad worked with the other pair.

The study lasted a total of 6 consecutive days. During the first day, I introduced the eighth graders to the research study. After confirming they had used functions such as $f(x) = x + 3$, made $(x, f(x))$ tables, and plotted the table points, we worked through the following problem:

Next year, $1000 must be raised for your freshman class fund. Some of this money will go toward a class party, and the rest will be saved for future events such as a junior-senior prom. To raise the money, you plan a golf outing in which $4 is charged for adults and $2 for students. What different numbers of people must attend to raise the money? (problem based upon Thomas & Thomas, 1997)

A discussion lead to a symbolic equation of the form $4x + 2y = 1000$. We then constructed a table of $(x=$adult, $y=$student) points (e.g., $(200,100)$, $(100,300)$) and graphed the line. After this, I introduced the general $Ax + By = C$ form and gave the same two goals given to students in the pilot study. I finished by showing how to access Lesson Graph from ClassNet and told the eighth graders how the preservice teachers at Iowa State were going to help them in discovering relationships.

During the next 4 days, each eighth-grade pair worked with Lesson Graph for 30-45 minutes every afternoon. Meanwhile, for approximately 1 hour each evening, the teachers
analyzed their assigned student protocols, viewed any student written replies, discussed the student thinking, and sent corresponding guidance. The researchers again served as participant observers with the teachers, and Amy had one group to herself. In addition, I traveled to the school each day to supervise and observe the students. The observation was not necessary as the study focused on the teachers. However, supervision was needed, and because I was the software developer of this new tool, I knew best how to trouble-shoot any problems. Incidentally, no problems with the tool occurred.

The teachers sent closure to their assigned student pairs on the last day. This consisted of a good-bye and a summary of their assigned pair's learning. I also informally asked the eighth graders about their thoughts and opinions of the activity.

Research Design, Data Collection, and Analysis

The research design was based upon an observational case study approach: One particular event (protocol analysis) was investigated and participant observation was the primary data gathering technique (Bogdan & Biklen, 1992; Merriam, 1988).

Multiple data sources and methods were used to support the credibility of data interpretation (Glesne & Peshkin, 1992). The utilization of participant observation in the preservice teachers' protocol sessions was essential in understanding the value and feasibility of protocol analysis. Participation occurred when the researchers and preservice teachers jointly discussed student thinking and considered guidance to send. I also observed the eighth graders, but did not participate in their simulation sessions. Data from the eighth grader observations were important, but not the focus of the study. One final interview was also conducted with each preservice teacher. Although these interviews were organized by an initial set of questions, deviation from these questions occurred when a topic merited deeper probing. All interviews
were audio taped and transcribed — except for an informal interview with the students after the study's completion. Finally, student-teacher messages and the students' protocol data served as electronic data sources.

Upon completion of the study, themes were constructed by first coding the data into a set of categories. Some categories were based upon the initial guiding questions, while others emerged from the data. These categories were then synthesized into themes and cross-checked with the preservice teachers during their final interviews. This cross-checking served to further enhance data credibility (Glesne & Peshkin, 1992).

Thematic Discussion

A Thinking Tool

One theme manifesting itself repeatedly was the need to think about student thinking and learning, mathematics, and future instruction. The hour-long sessions in which the teachers replayed the student protocols and constructed appropriate guidance were in-depth problem solving sessions: The task was to analyze current thinking and the goal was to promote future learning. The cognitive intensity of these sessions prompted Brad to comment that his "mind was blown" after one particular session.

Thinking about student thinking and learning.

In each session, teachers had to first replay the student protocols and analyze the thinking and learning. Teachers also read any student replies to their previous guidance. An excerpt from one student protocol (see Figure 3) prompted a typical dialogue between Brad and Terry:

Brad: They're bound and determined to figure out what C was.

...  
Terry: That was good that they got into the negatives.

...
Terry: I don't know what they mean by interval.

... Brad: I want to get them to level three thinking and I don't know how to say that... um. we could say how did you figure that out or what were you thinking? No, that sounds sarcastic... um, how did you decide to use C only?

Brad mentions level three thinking in his last comment. This goal was emphasized throughout the teaching sessions: the need to promote metacognitive skills that help guide domain independent thinking. Here, the metacognitive skill is to adjust only one variable (C) by holding the other two (A and B) constant. This is analogous to an important problem solving strategy mentioned by Polyá (1957) — breaking a problem into parts. Additionally, not only is it evident that Brad is attempting to promote the metacognitive skills (learning strategies) of the students, but he is also employing metacognitive skills by reflecting upon the optimal guidance to send.

In an earlier study also involving online collaboration between eighth graders and preservice teachers, one of Allen's (1997) teachers mentioned that the experience "let me get back into the mind of an eighth grader" (p. 61). In this study, the preservice teachers also seemed to be climbing inside the students' minds to think about each student pair's current thinking — and future thinking. In his final interview, Brad confirmed this notion by referring back to the protocol (see Figure 3) and discussion above:

When they sent the first transmission, it was something about C and getting farther away or something like that. I was trying to put myself where they were and think ok, what exactly are they trying to say?

Brad continued by discussing another attempt in helping students discover slope:

When we were sending the stuff to figure out slope, I was trying to think along the lines, ok, here I am tomorrow in their shoes. What can I say to get them to understand this? It was more of a try to think ahead. Instead of looking at what they said and thinking back to what they did and trying to think through their process, it was more thinking through their future process. If that makes sense?

Although Brad examined the current thought processes of the students and tried to place himself in their situation, he placed more emphasis on anticipating their future thought process and in
tailoring guidance accordingly. This is a difficult task and is further exemplified by Amy's experience of setting traps (discussed later in the 'general support for preservice teacher development' section). Nevertheless, trying to think as a student would and providing meaningful guidance was important to Brad.

Thinking about instruction.

After analyzing the student thinking processes, the teachers then had to send guidance for the next student session. This proved to be extremely troublesome for the teachers:

Terry: I think the hardest thing was nothing to do with the software. It was just trying to word things, you know, so we didn't just tell them. Sometimes it was hard to know what they were thinking because you couldn't see them... and their vocabulary sometimes lead you in different directions.

Amy: It was challenging to get them to find what you wanted them to. And to guide them, that was the hardest.

Brad: I think [the difficulty to guide] was just because we've always had the teachers tell us what it was and not try to like hint toward it and make us figure it out. So in our heads that's how we think we should be teaching: It's tell them what it is and make them understand it. This way we kind of had to hint at it and make them understand it that way, where they came up with it instead of being told. I think that's what made it hard -- to guide.

The difficulty in guiding could be attributed to a number of reasons. Two reasons are suggested by Terry: ambiguity and lack of direct contact. Because the teacher guidance occurred asynchronously with the student sessions, clarity of terminology was extremely important. If the students did not understand the meaning of the teacher guidance, or if the teachers did not understand the meaning of the student conjectures or replies to their guidance, a day was needed for further clarification. This caused both the teachers and the students to carefully word their communication. However, this still did not entirely eliminate the problem of ambiguity. Further, the lack of direct contact did not allow the teachers to witness important non-verbal cues. Any affective communication had to be worded in the teacher guidance or student replies.
Other reasons for instructive difficulty may be attributed to the instruction these teachers have been exposed to, teaching inexperience, or lack of domain expertise. Likely, Brad touched on the primary causal factor: frequent exposure to the telling model. Schifter and Simon (1992) state, "Themselves products of traditional mathematics education, teachers must redefine their ideas about mathematics learning and teaching" (p. 187). Another possible contributing factor is lack of teaching experience and the fact that no methods course had yet been taken. This is exemplified by the teachers' discovery of the importance of reinforcement:

Amy: I think it would both be beneficial if you guided first and then reviewed it. Because then they would figure it out for themselves, and then they would understand it more. Then, if you reviewed it with them to do the lecture part of it at the end, then it would make it more clear for the parts that they don't understand.

Terry: We didn't really reinforce all the stuff all the time what they were learning, and they did forget that first day. And on the last day... why didn't they remember this? They came up with this. And it was gone. So maybe in a classroom each day you're kind of overlapping and covering that stuff again where we didn't do that. We just kept moving forward.

Finally, even though these teachers all had experience with linear equations, they struggled with remembering concepts such as slope or perpendicularity. Subsequently, guiding students to discover these concepts became difficult at times when the teachers had to first remember or re-discover these concepts themselves. This may not be an obstacle if the teachers' background were in secondary mathematics education.

Providing constructive metacognitive guidance was also a struggle throughout the study. Both the researchers and the preservice teachers found this to be difficult. For example, during the first session, Brad and Terry's students adjusted one variable while keeping the others constant. This domain independent strategy enabled these students to not only discover parallel lines (see Figure 3) but also allowed them to discover formulas for the x- and y-intercepts (see Figure 4). The following teacher-student conversation ensued over multiple days:

[Teacher guidance. The student hypothesis is pasted in on the first two lines.]
>>To figure out the y' axis: c/b = the point on the y' axis.
>>To figure out the x' axis: c/a = the point of the x' axis.
>>*************
>> Can you explain your process that you used to get these two
>> formulas?
>> Can you use this information to graph 2x + 3y = 6?

[Student reply]
>> Again, we were just experimenting and found that this was true
>> of all the equations that we put in.
>> We were just keeping our eyes open to ways of solving it. Does
>> this answer your question?
>> Can you use this information to graph 2x + 3y = 6?
>> Yes, we can. [This was exemplified in the pair's protocol.]

[Teacher guidance]
> During your process of experimenting, you held two variables
> constant while changing the third. This is an important
> strategy to keep in mind for further use.
>
> How would you use this strategy in another class?

[Student reply]
We would use it in science class when doing experiments.

Because the students could not articulate the strategy they had used, the teachers directly called
the students' attention to the strategy. They then lead the students to think about that strategy in
another subject domain. The other student pair also required direct telling of this strategy.

Thinking about and doing mathematics.

Mathematics was the third primary focal point of teacher thinking. Teachers not only had
to think about mathematics content but also about domain specific and domain independent
metacognitive strategies that are valuable for learning. Further, the activity gave them a reason to
learn:

Amy: I was supposed to do something with a 0 and I just had no clue how to tell them
how to use 0... and then I went back to my room and I'm like ok, what does A mean? I
got to find out what A means for myself first.
Amy wanted to help her students find the importance of using 0: A domain specific strategy that simplifies mathematical equations. Additionally, this strategy's use ($A = 0$ or $B = 0$) leads to a content specific discovery of horizontal or vertical lines.

Thinking about student conjectures also gave the teachers opportunities to do mathematics. The teachers had to periodically work with the simulation by graphing their own lines to test the student's conjectures and look for counter-examples. The practice in constructing counter-examples is essential in helping teachers feel efficacious in alignment with mathematics reform (Smith, 1996). For example, one student pair thought they had discovered a process for generating perpendicular lines: They merely had to switch the $A$ or $B$ coefficient's sign (see Figure 5). However, because the absolute values of their $A$ and $B$ coefficients were equal, they did not know that $A$ and $B$ had to be switched in addition to taking the opposite. The students had failed to generalize by using knowledge of additional integral values to test. In response, because the teachers were not entirely certain if the student hypothesis was correct, they reviewed their ideas of perpendicularity by graphing their own lines. Subsequently, they derived a counter-example and sent the following guidance:

> You found perpendicular very well.
> Can you find it using $1x + 2y = 3$?

The ensuing cognitive conflict caused the students to rethink, test, and revise their conjecture the following day.

**General Support for Preservice Teacher Development**

Kagan (1992) defines five components of professional growth for novice and beginning teachers. Two of these components are:
1) An increase in metacognition: Novices become more aware of what they know and believe about pupils and classrooms and how their knowledge and beliefs are changing.

2) The acquisition of knowledge about pupils: Idealized and inaccurate images of pupils are reconstructed. Knowledge of pupils is used to modify, adapt, and reconstruct the novice’s image of self as teacher. (p. 156)

The ability to analyze student protocols appears to support both components. This is likely a direct result from the capability to solely think about student thinking and learning.

All three teachers gained in both components mentioned by Kagan. For example, Terry wrestled with wanting to tell students the answers throughout the study. While thinking about guidance on slope during her last session, Terry states:

Well, we can’t tell them it. That’s where I get stuck. They have come up with a lot more things than I thought they would without us telling them. I really didn’t expect them to.

Here, Terry reflects not only upon her inclination to tell, but also acknowledges that students may be intelligent enough to discover concepts without the need for direct telling.

In a final interview, Brad also ponders the effects of analyzing student protocols:

It basically gave me the idea, like a better idea of when I go into a classroom what I’m gonna need to hit on...I think this gave me a foundation of beliefs. I mean I really didn’t have much in terms of how they would think or learn... I guess it just gave me an insight into how they think.

Brad acknowledges his teaching inexperience but feels that he now has acquired enough knowledge of student thinking to form a basis for future encounters in this environment.

Amy also learned an important lesson about student thinking and learning when she sent a specific trap to promote the discovery of parallel lines:

> Relook at the equations -2x+-1y=-3 and -2x+-1y=3 and see if you
> can find a clearer relationship between them. Can you make other
> lines that belong to the same family (have the same relationships)?
> How do these equations differ?
Consequently the students drew the lines (see Figure 6), tested some more lines, and derived the following conjecture:

With the numbers we have tried, it seems as if on the y-axis the line touches is at C over B. On the x-axis, the line touches at C over A.

Amy was surprised when replaying the student protocol that evening. She was certain that a conjecture about parallel lines would be included somewhere. Instead, her guidance helped the students find important formulas for x- and y-intercepts which pertained to their original goal of drawing a line based solely on the Ax + By = C equation. Because Amy’s guidance took much reflective thought, one may wonder about the ability of artificially intelligent tools to promote particular learning through intelligent feedback. Would these tools have thwarted the students’ alternative discovery?

Particular Support for Enhancing Teacher Efficacy in Mathematics Reform

Upon examining the research, Smith (1996) writes that “teachers’ sense of efficacy is an important causal influence on their practice and their students’ learning” (p. 389). He believes that demands of mathematics reform undermine many teachers’ current sense of efficacy as they have been primarily apprenticed by the telling model. In conjunction with mathematics reform, he derives four components essential to helping teachers build and maintain efficacy: choosing appropriate problems; predicting student reasoning; generating and directing discourse; and judicious telling (p. 397). He feels that support systems must be developed to help teachers in these areas.

Preservice teacher analysis of Lesson Graph protocols and synthesis of corresponding guidance appears to support three areas listed above by Smith (1996): predicting student reasoning, generating and directing discourse, and judicious telling. For example, after the initial
pilot study, Terry correctly predicted that some eighth graders may graph random lines and would need help with strategies to construct orderly patterns: This was true of one eighth-grade pair and also true of many students in a previous study (Thomas & Thomas, 1997). Also, the ability to send and reply to electronic notes supported the discourse of mathematical ideas between teacher and student. Although asynchronous, teachers were given ample opportunities to guide and direct that discourse. Finally, Smith notes that judicious telling involves activities such as presenting counter-examples and useful terminology. The use of counter-examples was discussed above (i.e. perpendicular lines) and presenting useful terminology is exemplified by Amy’s response to her students’ previous conjecture of x- and y-intercepts:

[student conjecture]
With the numbers we have tried, it seems as if on the y-axis the line touches is at C over B. On the x-axis, the line touches at C over A.

[Amy’s response]
Good job on discovering where the line crosses the x-axis at the point (c/a, 0) and the y-axis at the point (0, c/b). These points are called the x-intercept and y-intercept. *pat on the back*

The students had discovered the concepts, and Amy further clarified what these concepts were.

Positive and Negative Implications of Asynchronous Communication

The time to discuss and reflect upon student thinking and learning supported the teachers in constructing guidance. Because experiencing a new form of teaching and learning mathematics was difficult for the teachers, the extra time was helpful. However, the students could have perhaps profited from synchronous communication. When asked about the positives and negatives of asynchronous communication, Amy responds:

There are plusses to both sides. It’s mostly plusses for the students when you do it at the same time because then they can go farther faster. But its better for the teacher if you wait because then you have that time to think. Plus, you have more time to look at what exactly they are doing so you can lead them in the right way. You can think about which way they should be going with what they are doing. So it kind of works both ways.
The other teachers expressed similar sentiments to Amy's. They realized that extra time was valuable for constructing guidance relative to the needs of the students. They also realized that synchronous communication while the students were working with the simulation would be more beneficial to the students — provided they knew what guidance to send. This would not only allow immediate clarification of any language ambiguities but also would give teachers the opportunity to ask important real-time questions helping students to immediately reflect upon their thinking (Schoenfeld, 1992). However, because the students could not immediately rely on teacher help, they may have been challenged to think more. This prompted the suggestion of future activities containing both synchronous and asynchronous components.

**Authentic, Motivating, and Valuable**

To constructivists, authentic activities are essential for learners to develop understanding (Choi and Hannafin, 1995; Simonson & Thompson, 1997). Myers (1993) believes that authentic tasks are challenging, risk-taking, and real. Choi and Hannafin (1995) write that authentic tasks allow learners first-hand experience in applying methods or strategies. When asked about this activity's authenticity, Brad and Terry responded:

Brad: Definitely. No matter how much a teacher can say, well this is probably what kids will do. I mean you actually have kids saying: Hey, I'm doing this. It gives you more real experience.

Terry: We worried about are we gonna tell them too much, or are we going to lead them totally the wrong way that confuses them more?

Brad and Terry illustrate the realness and risk-taking components. Terry exemplified Smith's (1996) beliefs that "making fundamental changes in teaching means taking risks" (p. 396). All three teachers underscored the authenticity of analyzing student protocols and found the synthesis of student guidance to be challenging.
For Amy, the authenticity of working with real students was internally motivating to learn more about teaching. Terry echoed Amy’s sentiments by stating:

It kept you wanting to come back. I remember coming back in and saying, well, I wonder what they did today? It was kind of that anticipation. I wonder what teachers do? Do they get that feeling? When we sent our replies we were thinking ahead how they were going to reply back.

Terry enjoyed the authentic nature of working with students and anticipating what their responses would be. Terry also displays her preservice naivete by reflecting upon the practice of teaching. She needs upcoming teaching experiences to resolve personal questions.

All three teachers believed the activity was valuable for teacher education. Brad sums up his feelings by stating:

This would be great if you could turn it into an entire college course and teach everything and anything this way... I would probably be one of the first ones over at the registrar... It's fun on my part. But I think this is one of those activities where its fun for everybody. I mean judging by the responses that the kids sent us back, they were having a blast. It made it fun for us.

Terry believed that teachers would be more effective in the classroom as a result of this activity, and Amy wished all her teacher education classes were this challenging. The teachers felt this activity would become even more valuable if future synchronous communication could be used after they became more comfortable with guiding students and anticipating problem areas.

The eighth graders also felt the activity was valuable for them. They liked this “new way” of doing mathematics and believed that other students should have the chance to experience the same activity with preservice teachers. They learned many important strategies and mathematical concepts while “doing” mathematics throughout the six day period. Truly, one benefit of telecommunications is the reciprocal learning which all connected participants may experience.
Feasibility and Future Research

Based upon the beneficial cognitive and affective influence that analyzing student protocols had on these preservice teachers, this tool’s use must be explored in future research. However, the tool may be judged more feasible in certain situations than in others.

Future research and feasibility considerations must account for the demand this tool may place on participants. The researchers had to sometimes participate more than desired, and the teacher sessions periodically resembled a cognitive apprenticeship where the researchers thought out loud how they might go about guiding the students. The cognitive demand on the preservice teachers was occasionally overwhelming and resulted in a need for strong scaffolding and support. However, the demand may be less with different teachers: These preservice teachers had not yet taken a methods course and struggled with the mathematics content. Nevertheless, because this study involved two researchers and only three preservice teachers, the tool was indeed feasible to use in this situation.

However, when considering use in a methods course of 20 or 30 preservice teachers, alternatives must be explored. An inviting and perhaps more feasible approach is to store real or simulated student protocols in a database. An entire method’s course of preservice teachers could then access the protocols, replay them, and discuss their proposed guidance in small or whole-class groups. Another possibility may be videotaping local students working with a non-networked version of the simulation and then discussing the video in class. This would capture more of the affective domain but may limit video access to class hours — unless the video were digitized and placed online. After these initial discussions, the preservice teachers could go online with actual classroom students and guide their learning. These new protocol sessions would then be stored for future teacher education use. Nonetheless, if all preservice teachers were to go online “live” with classroom students after initial practice and discussions in their method’s
course, a research or teaching assistant familiar with the content domain of the simulation would likely be needed to help the teachers.

Another alternative is to consider an approach similar to the pilot study. A simulation in a particular content domain could be targeted and preservice teachers who were familiar with that content domain could teach those who were not. For example, a future study involving Lesson Graph could link secondary education majors specializing in mathematics with elementary preservice teachers desiring to learn more about mathematics. Both groups may benefit from the experience as well as their future students. Depending upon class size, an extra teaching or research assistant may once again be necessary.

Other future research possibilities have been alluded to above. One future research path is the need to repeat the study with a different computer simulation. Will similar themes arise when a different content domain or computer simulation is used? Does the ability to analyze student protocols and synthesize guidance provide a strong impetus for invoking preservice teacher thinking across cases? Future research may also involve the same Lesson Graph simulation but target different preservice teachers. Will preservice or inservice teachers in secondary mathematics find the activity as challenging as the preservice teachers in this study? Would the cognitive demand be less and thus make the activity more feasible for an entire classroom of teachers in a method's course? Further, what if preservice teachers used the tool after the methods course? Would they struggle just as much? If so, perhaps the teaching of the methods course would need examination.

Research could also target different students. This study included eighth-grade boys who were motivated to volunteer. What would happen to other students in the same situation? Further, perhaps two research studies could simultaneously occur: one focusing on the students and the other on the preservice teachers. Even though students were observed in this study, the preservice
teachers received primary attention.

Finally, both the students and preservice teachers expressed the need for synchronous communication. This would help alleviate any language ambiguity that needed immediate clarification. However, the asynchronous aspect was invaluable in allowing the teachers to discuss the student thinking before sending guidance. Perhaps, after initial course discussions of student protocols, the teachers could go online synchronously instead of asynchronously. This would involve scheduling difficulty but may provide for valuable “real-time” instruction by the teachers where they can solely focus on student learning. For those schools and universities having the equipment, verbal and visual data (e.g. through CU-seeme) could possibly be transferred in addition to the simulation data. In this scenario, it is assumed that the elementary or secondary classroom teacher (or designee) would supervise the students.

Conclusion

This study formatively and qualitatively evaluated a tool’s feasibility. Regardless of distance, this tool takes advantage of a synergy between CMC and computer simulations and allows preservice teachers to analyze and guide student thinking. One salient outcome shows that a strong thinking environment for preservice teachers may result:

Brad: I don’t know if teachers would have to sit there and think as much as we had to. It really forced us to clear out the cobwebs and think pretty hard about what we were doing. It forced the teachers to think probably just as much as the kids were thinking.

Additionally, the pedagogic potential and feasibility of such a tool must be further explored by using different simulations, different participants, and synchronous communication. In large classes of preservice teachers, tool feasibility may be enhanced by analyzing a database of stored protocols and holding class discussions on proposed guidance. This may serve as practice for
future small group projects involving synchronous or asynchronous guidance with actual students. However, these small groups may still need strong mentoring support.

The teachers in this study learned much about mathematics, teaching, and student thinking. I would concur with Poole (1996) that telecommunications in general “has the potential to create a strong training environment for preservice teachers” (p. 251). Once again, more research is needed to examine the impact of CMC/telecommunications and associated technological partnerships on preservice teacher learning.

References


Linear Equations
General form: $aX + bY = c$

Figure 1. Lesson Graph student version.
Figure 2. Lesson Graph teacher version.
Figure 3. Student Conjecture: When you change 'C' only, parallel lines are added in the interval of the difference between the numbers that you put in.
Linear Equations
General form: \(aX + bY = c\)

Figure 4. Student Conjecture: To figure out the y-axis: \(C/B = \) the point on the y-axis. To figure out the x-axis: \(C/A = \) the point of the x-axis.
Linear Equations
General form: \(aX + bY = c\)

Figure 5. Discovering perpendicular lines but failing to generalize properly by using coefficient values different than 1 or -1.
Linear Equations
General form: $aX + bY = c$

Figure 6. Attempting to help students discover the concept of parallel lines.
Appendix A. Pilot Study Description and Organization
Study Description and Organization

I. Purpose of Study
To evaluate a system which gives preservice teachers more opportunities to interact with their future students' learning and thinking.

II. Purpose of Pilot Study
- To give "teachers" the opportunity to practice
- To test the system
- To give "students" the opportunity to learn more about relationships between linear coefficients and graphs; to provide an opportunity to practice how to hypothesize about proposed relationships; to learn more about technology and to think how it can be used.

III. Motivation/Reasoning - Literature and NCTM standards
A. Literature
- suggests that many preservice teachers reach classrooms with an inadequate knowledge about their students.

B. NCTM standards
- Problem solving -- which includes ... the ways in which one conjectures and reasons - must be central to schooling so that students can explore, create, accommodate to changed situations, and actively create new knowledge over the course of their lives.
- Mathematical power denotes an individual's ability to explore, conjecture, and reason logically, as well as the ability to use a variety of mathematical methods effectively
- Making conjectures, gathering evidence, and building an argument to support such notions are fundamental to doing mathematics.
- As students communicate their ideas, they learn to clarify, refine, and consolidate their thinking
- Increased attention in curriculum content to:
  K-4:
  - Thinking strategies
  - Study of patterns and relationships
  - Use of variables to express relationships
  - Problem solving strategies
  - etc.
  5-8:
  Representing situations verbally, numerically, graphically, geometrically, or symbolically
  - Identifying and using functional relationships
  - Developing and using tables, graphs, and rules to describe situations
  - etc.
  9-12:
  - The connection among a problem situation, its model as a function in symbolic form, and the graph of that function.
  - The use of computer utilities to develop conceptual understanding
  - etc.

IV. See Simulation Directions
V. Pilot Study Organization

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<tr>
<th>Mon</th>
<th>Tues</th>
<th>Wed</th>
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**Students**
- Split into two pairs
- Work with the simulation 3 times for about 30 minutes on Mon, Wed, and Fri. The following Monday, you will check the simulation again for any closure remarks from the teacher. This schedule may be stretched as we cannot determine how long it will take the teachers to respond, or we may ask you to work with the simulation one extra time one Monday.
- Assignment: You will need to fill out a questionnaire of open-ended essay questions about your experience: This will be your assignment for the class -- hand it to me by the following Friday (2/28). I may be in contact with you for any further questions.
- Because this is an evaluation, please be honest with your answers/opinions: Your answer will help us frame the longer study with the 7th or 8th graders and will provide insight into the value of the activity.

**Teachers**
- Split into two teams of three
- Each team will meet on Tuesday, Thursday, and Saturday or Sunday to review the student interactions. Each team is in charge of one student pair: You will replay your student pair's interactions and then provide guidance and feedback. You are also asked to replay the other student pair's interactions and use their hypotheses in constructing your feedback (e.g. Conflicting hypotheses between the two pairs could spawn some student thinking.). On Saturday (or Sunday), provide some sort of closure along with feedback. I will meet with you the first time and possibly other times as well.
- Each time you meet, please keep a short team journal of thoughts, ideas, and reactions. Use the assignment sheet handed out as a guideline for your thoughts. All of us will likely meet the following week to discuss the activity and journals and set the stage for the final study.
- Assignment (Virginia's students): After this, you will need to complete the assignment about your experience: This will be your assignment for the class -- hand it to me by the following Friday (2/28). I may be in contact with you for any further questions.
Simulation (Lesson Graph) Directions

I. Accessing Netscape3.0
Netscape3.0 (with Java enabled) is needed to run the simulation. This works best from an alpha or SGI Vincent workstation. Macs or PCs *from campus* work too, but they *must* have 3.0 and the Mac scrollbars don't work properly. If you do use a Mac or PC, use the ones in Durham. If none of the places below work for you, then let me know where you prefer — I would need to test the software from that location first.

A. Running Netscape3.0 from an SGI or alpha Vincent Workstation
- Best to use would be the SGI Indy's in 89 Durham or my workstation in 211! Other slower alphas can be accessed from 139 Durham. There are two sets of Vincent workstations in 139 Durham: The ones with the bigger monitors are alphas. There is also an alpha in Lagomarcino (N057?)
- Go up to the menu bar on the top of the screen. Click on Communications. Click on the arrow to the right of World Wide Web (WWW) and then click on netscape. If using an SGI, you will probably need to move the mouse a bit and then wait a few seconds for the screen to activate.

B. Other Macs or PCs
- The Mac PowerPCs in 206 Durham have netscape3.0 installed. Also feel free to set up a time with me to use either the Mac or the PC in 201 Durham (after 5pm and not from 6-9pm on Tuesday nights.)

II. Accessing the Simulation from Netscape3.0

Students
A. goto http://classnet.cc.iastate.edu/cgi-bin/main-menu
B. click on Graph and then click on Login
C. To play the role of a student click on your assigned student: Student, One or Student, Two
   Enter pilot-stud for the password and click on Menu
D. Click on LessonGraph and then click on Complete

Teachers
A. goto http://classnet.cc.iastate.edu/cgi-bin/main-menu
B. click on Graph and then click on Login
C. Choose your group's name: Teacher, One or Teacher, Two
   Use a password of pilot-tch and then click on Menu
D. Click on Gradebook
E. Click on LessonGraph and on one of the students. Then press Edit.

III. Running the Simulation

Students
A. Goals
- Find as many relationships as you can between the numerical coefficients of the algebraic linear equation (the a,b, c) and the resulting graphed lines.
- Determine how to graph a line directly from the equation without making a table.

B. Directions (also on the help page)
- Enter integers into the a, b, and c textboxes and click Plot
• “Clear Last” will clear the last drawn line
• “Clear All” will clear all the drawn lines
• When you have a relationship in mind:
  1) Click on “Post Idea”. This will create a new window entitled “Post Idea”
  2) Type in the relationship you thought of in the “Post Idea” window
  3) Click on “Post” in the “Post Idea” window
     (“View Ideas” will allow you to see your ideas posted thus far)
  4) You can use Post Idea to post any questions or thoughts you may have too.
• Reply To Teacher Notes
  - use this to read or reply to any teacher messages
  - Do not use this when you have an idea to post

Teachers
A. Goals
• Guide the students in discovering and conjecturing about the relationships. The
  primary goal is to help students learn how to reason and use appropriate strategies for
  working on any problem. In essence, the goal is to learn how to learn.
• The secondary goals would be the discovery of underlying concepts (e.g. x-intercept,
  y-intercept, slope).
• NCTM
  “Finally, our vision sees teachers encouraging students, probing for ideas, and
  carefully judging the maturity of a student’s thoughts and expressions.”
B. Directions (also on the help page)
• Get Data
  Get the student interaction data. These are organized by date_hour_minute. Hours
  range from 0 - 23 (midnight - 11pm)
• Step
  After getting the data, Step allows the teacher to step through the student
  interactions
• Reset
  Reset the student interactions to the beginning
• Send Notes to Student
  Use this to send messages to or read replies from your student. Use this to send
  helpful guidance or questions to the student.
Appendix B. Pilot Study Assignments
Student Assignment

Directions: Please give short essay answers to the following four questions. Question 0 asks for necessary background information. The bullets under questions 1-4 serve as a guide to answering that question. Please type them and slide them under my door in 211 Durham by Friday (2/28). I may get in touch with you later if I have a question about your answers.

0. Background -- Please answer all of these: a-d.
   a. What is your grade-level?
   b. What is your major? What grade-level do you desire to teach? Area of specialization?
   c. What high school math courses did you take? college?
   d. What is your attitude towards mathematics? (enjoy? indifferent? dislike?...)

1. What did you think about the Lesson Graph software? (Please give specific answers as it will aid in any further software design.)
   • In what ways did you find the software helpful or restrictive.
   • Was the software user-friendly and reliable? e.g. Was it easy to use? Did it break down?
   • Did this software help you in exploring and conjecturing about relationships between the symbolic equation (e.g. numbers entered for a, b, and c) and the resulting graphed line? How? Could the same thing be done as easily without technology?
   • How could this software be improved?

2. What did you think about the activity?
   • Do you perceive this as a potentially valuable activity in teacher education? (Consider the use of actual students and likely an extended activity of longer than a week.)
   • Is this activity worth the time it requires? Could it be better structured? How many sessions would be needed to start feeling comfortable with graphing?
   • Do you perceive this activity as being a real or authentic learning experience?
   • What do you think the learning goals of an activity like this should be? For preservice teachers? For secondary students?
   • What is the value of conjecture in mathematics?

3. What did you learn?
   • Did you learn any new relationships between the a, b, and c coefficients and the resulting graphed lines?
   • Did the teacher suggestions or questions help you? If so, in what ways?
   • Were there any learning strategies that were helpful? Would these strategies be helpful in other problem solving situations?

4. What do you think about technology?
   • What are your feelings about technology? Are you comfortable with it? Do you like using it? Do you see it as a valuable tool in education?
   • What are the positive and negative aspects of using a telecommunications tool such as Lesson Graph to communicate with secondary or elementary students?
   • Did your attitude about technology or perception of its value change as the result of this short pilot study. If so, how?
Teacher Assignment

Directions: Please give short essay answers to the following four questions. The bullets under each question serve as a guide to answering that question. Think about the questions during the pilot study and answer immediately after the study's completion. Please type them and slide them under my door in 211 Durham by Friday (2/28). I may get in touch with you later if I have a question about your answer.

1. What did you think about the ClassNet/Lesson Graph software? (Please give specific answers as it will aid in any further software design.)
   - In what ways did you find the software helpful or restrictive.
   - Was the software user-friendly and reliable? e.g. Was it easy to use? Did it break down?
   - Did this software help you in exploring how students think? How? Could the same thing be done as easily without technology?
   - How could this software be improved?

2. What did you think about the activity?
   - Do you perceive this as a potentially valuable activity in teacher education? (Consider the use of actual students and likely an extended activity of longer than a week.)
   - Is this activity worth the time it requires? Could it be better structured?
   - Do you perceive this activity as being a real or authentic learning experience?
   - What do you think the learning goals of an activity like this should be? For preservice teachers? For elementary or secondary students?
   - What is the value of conjecture in mathematics?

3. What did you learn?
   - Did you become more aware of how students think and learn?
   - Did your beliefs of how students think and learn change?
   - Did you learn anything more about mathematics and relationships between symbolic linear equations and graphed lines?
   - What learning strategies were most beneficial in this activity to give to students? Would these strategies be helpful in other problem solving situations?

4. What do you think about technology?
   - What are your feelings about technology? Are you comfortable with it? Do you like using it? Do you see it as a valuable tool in education?
   - What are the positive and negative aspects of using a telecommunications tool such as ClassNet/Lesson Graph to communicate with secondary or elementary students?
   - Did your attitude about technology or perception of its value change as the result of this short pilot study. If so, how?
Appendix C. Consent Forms
Informed Consent Form

This study will evaluate the feasibility of a tool designed to give preservice teachers more experience in analyzing and guiding student learning. We need your input in designing this tool.

Participants will be asked to interact with 4 junior high students for approximately 1 week (every day). I (principal investigator) may be in contact with you after this time period for any further information that may be needed or clarified. Student/teacher interactions will take place over the Internet via a computer simulation:

1) Two pairs of students at a remote site will use a computer-based simulation to explore mathematical concepts. Their work will be recorded.
2) Each preservice teacher group will meet, analyze both recordings, and then send feedback to the student pair they are assigned.
3) Steps 1) and 2) will be repeated for about one week.

During this interaction, participants are asked to keep a diary of thoughts and reactions. Researchers (principal investigator and/or major professor) will lead an initial orientation session and may serve as participant observers in other meetings. The researchers will also periodically interview the participants. If the participants consent, these interviews will be taped.

All information obtained will be confidential to the researchers (principal investigator and major professor), research participants, and the supervising teacher. This information will be disclosed only with your permission. Any tapes will be transcribed only by the principal investigator and will be destroyed by 8/1/97. Names in the resulting Ph.D. dissertation or in any publications or presentations will maintain confidentiality through the use of pseudonyms, and data gathered throughout the study will be checked with research participants for accuracy.

Participants will likely benefit by learning mathematics, obtaining experience in analyzing and guiding student thinking about mathematics, and in gaining insight into the use of technology in education. There is no risk anticipated in this study.

Your decision whether or not to participate will not prejudice your future or future relations with Iowa State University. If you decide to participate, you are free to discontinue participation at any time without prejudice.

If you have any questions, do not hesitate to contact me. I can best be reached either by e-mail (mvg@iastate.edu) or by phone (515-292-0887 - Home; 515-294-4907 - Work). I appreciate your support and cooperation.

Sincerely,

Mark J. Van Gorp (principal investigator)

I have read the above information and voluntarily agree to participate.

Name: ______________________ Signature: ______________________

(Please print)

Date: _______________________ (mth/day/yr)
Dear Dan:

As a graduate student in Curriculum and Instruction at Iowa State University, I am interested in providing more opportunities for preservice teachers (education majors) to interact with their future students. My colleagues and I at Iowa State have developed a computer simulation which supports these opportunities over the Internet. Our agenda is to conduct a study with the purpose of evaluating this tool's potential in teacher education.

We would like to use Pella Christian Grade School to conduct this study. The students involved will likely learn more about mathematics and the preservice teachers at Iowa State will learn more about teaching mathematics. A consent form is being sent to the parents of the students involved. Further, we would like to have your permission to perform this study at Pella Christian Grade and to use one networked computer for access to this simulation. If you consent, please sign below.

Thank you for your cooperation. We anticipate this study to be beneficial to all participants involved.

Mark J. Van Gorp
Ph.D. Candidate
Iowa State University
515-292-0887
mvg@iastate.edu

Please circle your response and sign below.

I am willing / not willing to allow this study to take place at Pella Christian Grade.

Signature: ____________________________

Date: ____________________________ (mth/day/yr)
Dear Parents/Guardians:

As a graduate student in Curriculum and Instruction at Iowa State University, I am interested in providing more opportunities for preservice teachers (education majors) to interact with their future students. My colleagues and I at Iowa State have developed a computer simulation which supports these opportunities over the Internet. Our agenda is to conduct a study with the purpose of evaluating this tool's potential in teacher education.

The computer simulation (known as Lesson Graph) allows students to explore and discover mathematical relationships between linear equations and corresponding graphed lines. Additionally, the simulation allows preservice teachers to look at the student explorations and to subsequently provide feedback to the students.

Students will be asked to work with this simulation at school for approximately 1 week (every day; about 30 to 45 minutes each time). Students will work in pairs and their learning will be guided not only by their own ideas but also by their preservice teacher helpers at Iowa State. Students will directly benefit by learning more about the nature of mathematics, linear equations, and positive uses of technology. Meanwhile, preservice teachers will likely learn more about their future students' learning and thinking capabilities. There are no known risks that are involved with this study.

Students will be supervised either by myself or by a supervisor designated by Pella Christian Grade. If needed, the students may be informally asked their opinions on the simulation and the value of the Internet activity. Results obtained from the study will be used in writing a Ph.D. dissertation and also possibly published or presented at a conference. The identity of your student will not be known (Pseudonyms will be used on-line and in any reports.), and all data will be destroyed after analysis of the study. Although student identity is confidential and no risks are foreseen, you may request, at any time, that your child be withdrawn from the study.

We are excited about the potential of this study and the possibility of your child's involvement. Please do not hesitate to contact me (Mark Van Gorp) with any questions. My phone number and e-mail address are given below. You may also contact Mr. Veenstra at Pella Christian Grade for additional information.

Please sign and return the bottom portion of this letter to Mr. Veenstra by Friday, March 7. Thank you for your cooperation.

Sincerely,

Mark J. Van Gorp
Ph.D. Candidate
Iowa State University
515-292-0887
mvg@iastate.edu

Dr. Rex Thomas
Major Professor

Please circle your response and fill in your child's first and last name.

I am willing / not willing to have my child_________________________ participate in this study.
Parent/Guardian Signature:_______________________________________

Date:____________________ (mth/day/yr)
Appendix D. Final Teacher Interview: Guiding Questions
Final Interview -- Guiding Questions

Personal
- Grade Level
- major
- Math courses previously taken?
- Teaching experience
- Attitude towards math.

Software
- Was it easy to use?
- In what ways did you find the software helpful or restrictive?
- In general, how did being able to replay back the students data help you? Is the replay mechanism much more helpful than analyzing ASCII data?
- Did this software help you in exploring how students think? Could the same thing be done without technology?
- How could the software be improved?

Change
- Did your beliefs of how students think and learn change?
- Did your outlook on the teaching/learning process change? telling or guiding?
- Was it difficult to guide student learning?
- Did your attitude about technology or perception of its value change as the result of this short pilot study?
- Did your outlook on what mathematics is change?

Authenticity
- Did you find this activity challenging? Which aspects?
- Did you find this activity real?
- Were you motivated to learn rather than just receive college credit?
- Was there any risk taking involved?
- Do you perceive this activity as valuable in teacher education?

Time
- Did having the time to discuss feedback to the students help you?
- If you were to do this activity a second time, would you like to do it synchronously?

Learning/thinking
- Did you learn more about mathematics? Ways of doing math? Conjecturing?
  - math content? (x-int, y-int, slope, etc.)
  - metacognitive skills? Power of 0, changing one variable
- Did you learn more about how students think and learn? Was it easier to focus on student thinking than in a real classroom?
- Did you learn more about yourself as a teacher?
- What were the different things you had to think about? Did you ever find yourself trying to get inside the student's heads?
• Do you think you could predict or anticipate how future students are going to think in graphing?

Overall?
• Did you find this as a valuable activity that future education majors (those in sec. ed.) should be exposed to?
• What are the positive and negative aspects of using a telecommunications such as ClassNet/Lesson Graph to communicate with students? affective -?
Appendix E. Discovering Perpendicular Lines: Two Day Sequence of Protocol Snapshots
Day 1: In response to the teachers' suggestion to discover perpendicular lines, the students began by making strategic use of 1's and 0's.
Linear Equations
General form: \(aX + bY = c\)

(1) \(1X + 1Y = 1\)

(2) \(1X - 1Y = 1\)

Day 1: Negative numbers are used to discover an initial notion of perpendicularity.
Linear Equations
General form: $aX + bY = c$

Day 1: The notion is tested by adding two additional perpendicular lines with negative C and negative A coefficients. The students discover that changing the sign of an A or B coefficient produces perpendicular lines but fail to generalize properly through knowledge of additional integral values.

Student response: Yeah! We did it. Look through our equations: $lx+ly=1$, $lx*-ly=1$. 
Linear Equations
General form: $aX + bY = c$

Day 1: Students discover additional perpendicular lines by using $0$ (First two lines are on the $x$- and $y$-axes.). However, they do not relate this discovery to the previous discovery of A or B sign transformation.
Day 2: Preservice teachers present a counterexample to the students' belief that changing A and B only produces perpendicular lines. The students are now asked to find a line perpendicular to \( lx + 2y = 3 \). Here, the students start with \( lx + 2y = 3 \) and use what they learned the previous day by changing the signs of the A and B coefficients. However, cognitive conflict is now experienced: The graphed lines are not perpendicular.
Linear Equations
General form: \( aX + bY = c \)

Day 2: A different approach is now taken to remedy the misconception: By changing both the coefficients and signs, a pair of perpendicular lines is almost discovered.
Day 2: The students once again make strategic use of previously constructed knowledge: They had made perpendicular lines with 0's and 1's the day before. A realization now exists that changing the A and B coefficients also creates perpendicular lines.
Day 2: Students use their knowledge that changing signs or values of A and B can create perpendicular lines. At last, a line perpendicular to $1x + 2y = 3$ is constructed.
Linear Equations
General form: \( aX + bY = c \)

Day 2: Their new idea is now tested and generalized to other integral values.
Student response to original problem of constructing a line perpendicular to \( 1x + 2y = 3 \): Switch 1 and 2 around and make the 1 a negative or \( 2x + -1y = 3 \)
GENERAL CONCLUSIONS

Reflections

In general, the primary goal of this dissertation was to examine and improve CMC use in preservice teacher education. A newly designed CMC tool was explored as a means for preservice teachers to experience student-centered pedagogy and construct knowledge of their future students. It was hoped that utilization of this tool could help meet demands of technology integration into the preservice curriculum (Byrum and Cashman, 1993), provide meaningful learning opportunities advocated by teacher education reform (Darling-Hammond, 1992), and contribute new learning experiences not possible with current CMC tools such as e-mail.

Outcomes and information provided in all three papers collectively contributed to the attainment of this goal. An examination of the research in the first paper showed that CMC integration into the preservice curriculum currently reveals positive attitudes and evidence of learning—despite the problems that are occurring. In response to these problems, two basic needs were identified: the need to emphasize preservice teachers' learning and the need to construct and consider new CMC tools which may support that learning. This lead into the second paper's description of one tool that may potentially provide this support. This paper described the design characteristics of ClassNet and how ClassNet is primarily used to handle management tasks in virtual classrooms. It also presented concrete examples of ClassNet's use and a brief vision of how ClassNet may be integrated into preservice teacher education. The third paper investigated an implementation of ClassNet's use with preservice teachers. This study indicated that ClassNet did facilitate the learning of preservice teachers and may serve as a learning tool in the preservice curriculum.
Nevertheless, the dissertation does have its strengths and weaknesses. Its primary weakness is related to the nature of the tool it highlights. ClassNet is a developing technology designed to meet the needs of virtual classroom management. Consequently, its design characteristics are not tailored specifically for preservice teacher education, and its utilization will require a programmer in certain instances. This weakness may dissipate with additional ClassNet development; or, it may require the development of a similar tool geared more toward the education of teachers. Another weakness includes the slightly non-traditional research review given in the first paper. In some respects, this review resembled more of an informal summary; however, this was due to the largely informal nature of the evolving research it represents. Finally, because the final study was an initial in-depth attempt at qualitative inquiry, it is likely that research techniques could be improved.

Many strengths of this dissertation were mentioned in the general introduction. In essence, the first paper contributed a needs assessment and a vision of CMC use that may not yet be realized. The second paper introduced a new tool which may aid not only in virtual classroom management but also in the education of preservice teachers. The third paper presented the creation and evaluation of a new learning experience that held implications of future support in mathematics reform. Overall, a vision of how new developments in CMC can support the needs of preservice education was given along with opportunities for future research.

Future Research

In light of the presented papers and resulting outcomes, numerous directions for future research are apparent. Some of these directions are based upon instructional software development; whereas others are based upon the investigation of CMC in preservice teacher education.
First, there is a need to go beyond e-mail and explore the development and utilization of new technologies in preservice teacher education. Although e-mail activities have enhanced the preservice curriculum, e-mail's limitations include its non-multimedia nature, its failures to capture the process of problem solving, and its requirement for individual student e-mail addresses that are uncommon in elementary or secondary institutions. The construction or modification of new technologies will likely eliminate some of these limitations and create additional learning opportunities. In particular, continued development of ClassNet is advocated as well as the development of other CMC technologies that may require closer ties between education and computer science.

Second, the pedagogic impact of CMC in preservice teacher education must continue to be investigated. Research must explore the learning of both preservice teachers and connected elementary or secondary pupils. This focus on learning will provide deeper insight into an area that has already revealed many positive attitudinal outcomes. Research must also examine the learning facilitated by new CMC tools such as ClassNet. The evaluation of ClassNet's support for protocol investigation alone has revealed numerous research avenues. For example the value of protocol investigation could be explored with different participants, different simulations, and different settings. Additionally, synchronous or visual components could be studied in addition to protocol activities that are modified for use with an entire classroom of preservice teachers. Because these research possibilities arose from the study of one ClassNet feature, the creation and exploration of additional activities related to ClassNet or other new CMC technologies will likely contribute much more to a growing area of research.
Conclusion

The utilization of CMC in the preservice curriculum has much to offer the educational needs of preservice teachers. One important need is to provide preservice teachers with meaningful opportunities to develop as teachers and experience student-centered pedagogy. The already extensive use of e-mail and the current exploration of ClassNet are only beginning attempts in using technology to meet this need. Future technological advancements and the creation of new CMC tools will greatly expand on these attempts by providing enhanced opportunities for visual and verbal communication. However, the challenge will be for teacher educators to effectively use this technology to support learning and to work with others to envision and develop new tools like ClassNet which may increasingly foster the growth of preservice teachers.

References


Throughout my studies at Iowa State University, I have received support from many people. Some of these people in particular contributed to the completion of this dissertation and the subsequent doctoral degree.

Dr. Rex Thomas and Dr. Pete Boysen deserve a special thanks. Rex’s vision and helpful editing comments contributed immensely to the product and process of my writing. I will always be grateful for his efforts in serving as my major professor and in being an integral part of ClassNet’s evaluation. Additionally, without Pete’s programming hours and technology insights, this dissertation would not have been accomplished. As a joint developer of ClassNet with Pete, I always admired his in-depth knowledge of software and software development as well as his work ethic and positive attitude — even when software troubles emerged. I also appreciated the flexibility that both Rex and Pete gave me while working as a research assistant in Iowa State’s Computation Center.

Dr. Johnny Wong, Dr. Ann Thompson, and Dr. Larry Bradshaw contributed valuable time as committee members (in addition to Rex and Pete). I would like to thank Dr. Wong for teaching the computer networking class which I audited. The knowledge gained from his class helped me build the software server that is central to ClassNet’s simulation tracking. I am also grateful to Dr. Thompson for the educational insights she provided both in her Technology and Teacher Education course and on my dissertation research papers. Last, but not least, I appreciated the helpful comments and sincere kindness expressed by Dr. Bradshaw. Even though I did not take a course with Dr. Bradshaw, I always valued the interest he showed in my work.

Mr. Doug Veenstra, his four eighth-grade mathematics students, and others at Pella Christian Grade School played instrumental roles in making the evaluation study a success. I will
always be grateful to Doug for his extra efforts and to the four eighth graders for their responsibility and willingness to participate. Pella Christian Grade was a phenomenal institution to work with.

The three preservice teachers were also vital contributors to the success of the evaluation study. Their dedication and dependability were appreciated, and I enjoyed working with each of them.

Finally, my family and friends contributed in many seen and unseen ways. I am thankful for their support in my completion of this educational endeavor.