Occasional Paper Series

Occasional Paper No. 6

Appalachian Collaborative Center for Learning, Assessment and Instruction in Mathematics

Review of Distance Education Literature

Robert Mayes
West Virginia University

February 2004

ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places.

ACCLAIM Research Initiative
All rights reserved

Address: 210A McCracken Hall
Ohio University
Athens, OH 45701-2979

Office: 740-593-9869
Fax: 740-593-0477

E-mail: howleyc@ohio.edu
Web: http://acclaim.coe.ohiou.edu/

Funded by the National Science Foundation as a Center for Learning and Teaching, ACCLAIM is a partnership of the University of Tennessee (Knoxville), University of Kentucky (Lexington), Kentucky Science and Technology Corporation (Lexington), Marshall University (Huntington, WV), University of Louisville, West Virginia University (Morgantown), and Ohio University (Athens, OH).

This material is based upon the work supported by the National Science Foundation Under Grant No. 0119679. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Review of Distance Education Literature

By Robert Mayes
West Virginia University

The Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics (ACCLAIM), an NSF Center for Learning and Teaching, is establishing a series of undergraduate and graduate mathematics and mathematics education courses with the goal of increasing the capacity for leadership in mathematics education in rural places. In an effort to offer quality courses and programs through computer-mediated distance learning, ACCLAIM commissioned a review of the literature to determine best practices. A review of research and expository articles on distance education was conducted, with a restriction to post-1990 articles. Mathematics distance education course articles were an additional focus.

While many articles were reviewed, two articles offering summaries of research through 1999 stand out. *What's the Difference?* (Merisotis & Phipps, 1999) provides a summary of the current state of research on distance education up to 1999. *Quality on the Line: Benchmarks for Success in Internet-based Distance Education* (Carnevale, 2000) studies top U.S. distance education programs to determine components of quality distance education. Both of these studies were conducted by the Institute for Higher Education Policy. The review begins with a brief summary of these two reports and then extends to articles that have a distance education in mathematics focus or are post-1998.

Institute for Higher Education Policy Reports

The "No Significant Difference Phenomenon" (Russell, 1999) is a compilation of

more than 355 sources dating back to 1928 that suggest the learning outcomes of students in distance education courses are similar to those participating in traditional classrooms. *What's the Difference?* disputes the conclusions of that work. Merisotis and Phipps reviewed research, how-to-articles, and policy papers from 1990 through 1999 to provide a basis in theory for distance education policy. They found that the vast majority of articles on distance education were opinion pieces, how-to-articles, and second-hand reports with no quality research basis. This current review of the literature found that little has changed since 1999; there is still a lack of quality research on distance education. Merisotis & Phipps identified only about 40 articles that were classified as original research, including experimental, descriptive, correlational, and case studies, and classified them as having three broad measures of the effectiveness of distance education:

- Student outcomes, such as grades and test scores,
- Student attitudes about learning through distance education,
- Overall student satisfaction toward distance learning.

The majority of the original research articles indicated that distance education had positive outcomes in all three of these areas. The experimental studies conclude that distance learning courses compare favorably with classroom-based instruction, with students receiving similar grades or test scores and having similar attitudes towards the course. The descriptive analysis and case studies conclude that students and faculty have a positive attitude toward distance learning. Merisotis and Phipps found significant problems with the quality of the research conducted, however, and advised that the lack of quality renders many of the findings inconclusive. They identified four quality issues with respect to the research in distance education:

- Failure to control for extraneous variables;
- Lack of random selection of students;
- Poor or no reliability and validity for the instruments;
- Failure to control for attitudes and beliefs of students and faculty causing reactive effects (novelty effect or John Henry effect)

Despite these warnings, three broad implications for distance education were derived from the review.

- First, the notion of "access to college" in the distance learning context is unclear. The efficacy of computer-mediated learning is a key concern, since it requires special skills on the part of students and instructors. Questions that need to be answered are: What is the quality of the access? Does the student have the necessary skills to use the technology? What are the best ways to participate in asynchronous communication? Is there adequate technical support? Will cost of hardware, software, or both be prohibitive for students?
- Second, technology can leverage faculty time, but it cannot replace most human contact without significant quality losses. Faculty in distance education take on the roles of content experts, learning process designers, process implementation managers, motivators, mentors, and interpreters.
- Third, technology is not the most important factor affecting student learning and student satisfaction. More important factors are learning tasks, learner characteristics, student motivation, and the instructor.

Merisotis and Phipps finish by concluding that improving distance education is a

question not of technology, but of pedagogy – the art of teaching. Perhaps this finding is not surprising, considering the report was commissioned by the American Federation of Teachers and the National Education Association. They finish with a call to re-examine the Seven Principles for Good Practice in Undergraduate Education promulgated by the American Association for Higher Education (Chickering & Gamson, 1987) as a focus for distance education. The AAHE's principles of good practice include those methods that:

- Encourage contacts between students and faculty,
- Develop reciprocity and cooperation among students,
- Use active learning techniques,
- Give prompt feedback,
- Emphasize time on-task,
- Communicate high expectations,
- Respect diverse talents and ways of learning.

The researchers identify gaps in the research they believe require further investigation:

- Measuring the effectiveness of total academic programs taught using distance education versus student outcomes for individual courses. A focus on student outcomes with respect to cognitive skills; verbal, quantitative, and subject matter competence; critical thinking skills; attitudes and values; and moral development.
- Accounting for student differences versus the illusory "typical learner." Differences include gender, age, educational experience, and motivation.
- Excessive drop-out rates of students enrolled in distance courses. How

can student persistence be improved? The need to control for self-selection due to excessive drop-out rates.

- Effect of student learning styles on selection and use of technology.
- Accounting for the interaction of multiple technologies versus the impact of individual technologies.
- Need to develop a theoretical or conceptual framework for research on distance education.
- Effectiveness of digital libraries. Anecdotal evidence suggests that distance courses suffer from a limited variety of resources available from digital libraries.

The Institute for Higher Education Policy followed up the *What's the Difference?* (Merisotis & Phipps, 1999) report with a report on what constitutes quality distance education. *Quality on the Line: Benchmarks for Success in Internet-based Distance Education* (Carnevale, 2000) was a case study of six institutions identified as having quality distance education programs. A comprehensive literature search was conducted that identified 45 benchmarks for conducting quality distance education. The six institutions were surveyed using a Likert Scale instrument and interviewed to assess the degree to which they incorporated the benchmarks in their programs. Analysis resulted in the elimination of 13 benchmarks and the addition of three new benchmarks, yielding 24 benchmarks for quality distance education. The 24 benchmarks are separated into seven categories. A summary of those benchmarks by category follows:

<u>Institutional Support Benchmarks</u>

- A documented technology plan that includes electronic security measures

(i.e., password protection, encryption, back-up systems) is in place and operational to ensure both quality standards and the integrity and validity of information.

- The reliability of the technology delivery system is as failsafe as possible.
- A centralized system provides support for building and maintaining the distance education infrastructure.

Course Development Benchmarks

- Guidelines regarding minimum standards are used for course development, design, and delivery, while learning outcomes—not the availability of existing technology—determine the technology being used to deliver course content.
- Instructional materials are reviewed periodically to ensure they meet program standards.
- Courses are designed to require students to engage themselves in analysis, synthesis, and evaluation as part of their course and program requirements.

Teaching/Learning Benchmarks

- Student interaction with faculty and other students is an essential characteristic and is facilitated through a variety of ways, including voice-mail, e-mail, or both.
- Feedback to student assignments and questions is constructive and timely.
- Students are instructed in the proper methods of effective research, including assessment of the validity of resources.

Course Structure Benchmarks

- Before starting an online program, students are advised about the program to determine (1) if they possess the self-motivation and commitment to learn at a distance and (2) if they have access to the minimal technology required by the course design.
- Students are provided with supplemental course information that outlines course objectives, concepts, and ideas, and learning outcomes for each course are summarized in a clearly written, straightforward statement.
- Students have access to sufficient library resources that may include a "virtual library" accessible through the World Wide Web.
- Faculty and students agree upon expectations regarding times for student assignment completion and faculty response.

Student Support Benchmarks

- Students receive information about programs, including admission requirements, tuition and fees, books and supplies, technical and proctoring requirements, and student support services.
- Students are provided with hands-on training and information to aid them in securing material through electronic databases, interlibrary loans, government archives, news services, and other sources.
- Throughout the duration of the course/program, students have access to technical assistance, including detailed instructions regarding the electronic media used, practice sessions prior to the beginning of the course, and convenient access to technical support staff.
- Questions directed to student service personnel are answered accurately

and quickly, with a structured system in place to address student complaints.

Faculty Support Benchmarks

- Technical assistance in course development is available to faculty, who are encouraged to use it.
- Faculty members are assisted in the transition from classroom teaching to online instruction and are assessed during the process.
- Instructor training and assistance, including peer mentoring, continues through the progression of the online course.
- Faculty members are provided with written resources to deal with issues arising from student use of electronically accessed data.

Evaluation and Assessment Benchmarks

- The program's educational effectiveness and teaching/learning process is assessed through an evaluation process that uses several methods and applies specific standards.
- Data on enrollment, costs, and successful and innovative uses of technology are used to evaluate program effectiveness.
- Intended learning outcomes are reviewed regularly to ensure clarity, utility, and appropriateness.

These benchmarks provide a good starting place for developing a quality distance education program. The report focused on Internet-based distance education, since the NCES report (Lewis, Snow, Farris, & Levin, 1999) indicates that Internet-based distance education is the most prevalent and fastest growing medium. At least 58% of institutions

offering distance education offer Internet-based courses.

In this report Carnevale identifies some specific recommendations made in the in-depth interviews:

- In selecting faculty, institutions should work with the willing. Faculty who show intrinsic interest in distance education will do the best job.
- Accounting for learning styles was not seen as important in developing distance education courses, due to lack of reliable research on learning styles.
- Review of distance courses should parallel that of traditional courses, and not be constrained by excessive overview.
- Development of distance education courses must take into consideration the technology the students possess. Cutting edge must not become the bleeding edge.
- Module learning is inappropriate; students will collaborate much more in an on-line environment and should not be constrained.
- Students need to communicate almost on a daily basis, not just once a week. Interactivity requires not only e-mail and voice-mail, but a conference system (discussion board, chat room, or both.)
- On-line courses have characteristics unique to the technology, which allows the exploration of new pedagogical models. Do not just emulate the traditional classroom; take advantage of the power of the technology.
- Given the dynamic and innovative characteristics of Internet-based distance education, hard and fast rules on how much work should be

accomplished in a specific time period or the precise response time for faculty is inappropriate. Faculty and students must agree on when assignments need to be completed and returned, however.

- It is inappropriate to introduce a benchmark on maximum class size, however, several faculty recommended a maximum size of 20 to 25 students. Others felt large-enrollment courses (300) could be conducted successfully, and that the determining factor was faculty course load more than student outcomes.
- Peer networks in a web-based environment are effective in addressing higher student feedback demands. Such networks can allow for academic and social interaction.
- Education institutions should provide technical help through a variety of means, such as 800 numbers, e-mail, chat rooms, and on-line tutorials. They should provide one-stop shopping where students can receive student support services such as academic program information.
- Pedagogy of on-line learning must be part of professional development for faculty teaching in distance education programs.
- Data on the health of the program needs to be collected and analyzed in six areas: student demand, student retention, student satisfaction, faculty satisfaction, student achievement, and financial efficiency. Often distance courses have a bipolar grade distribution of A or F/W.

Distance Education Research: Post-1998 or Math Focus

To support the two major reports cited above, a review of the literature was conducted with two restrictions: articles were within the past five years or articles had a focus on mathematics distance education. Twenty-nine articles were collected, including the two summary articles reviewed above. The other 27 articles are evenly divided between expository (14) and research (13) articles. The research articles were classified as quantitative (8) and qualitative (6), with one having elements of both methodologies. The research or courses occur at multiple grade levels including high school (4), community college (3), and college (18). The subject areas varied, and included math (11), education (4), English (2), computing (2), physics, statistics, medical care, and four articles with multiple subject areas combined. The modes were even more varied, with the majority using a computer mediated, Internet-based mode (13). Most courses used multiple modes, including telecourse or two-way video (4), CD or video tape (5), whiteboard (3), telephone bridge (2), synchronous audio (2), computer algebra system (2), on-site facilitator (2), textbook-centered (2), fiber optics, programming, or a tutorial system. The focus of study was heavily weighted towards affective issues (18) versus cognitive issues (4).

Literature Reviews

The research articles provide insights through literature reviews, findings, and conclusions, while the expository articles provide experience-based recommendations. This review begins by summarizing the literature reviews.

Inman and Kerwin (1999) encapsulate the changing role of the instructor in distance education, where student-teacher interactions are conducted without the visual cues available through direct eye contact. One result is a shift in role to content

facilitator (Smith, Gordon, et. al., 2001). Students appear to be more comfortable with this shifting role then are teachers. The main predictor of student satisfaction is the amount of information transferred, with more information resulting in a higher level of satisfaction. Students are drawn to distance education courses for their convenience and flexibility (Sullivan, 2001), individualized instruction, and measure of anonymity. This measure of anonymity is a positive aspect of distance education for females. Distance courses should require regular contact, eliminate academic isolation, and hold opening face-to-face meetings with a focus on technology demonstrations, course expectations, and collection of student pictures for on-line display.

Sunderland (2002) provides a literature review focused on distributed learning aspects of distance education. He concluded that distance education instructors fail to adequately account for the time required to complete on-line assignments. This failure, when combined with students' mistrust, misunderstanding, and misconceptions about course material, led to increased dropout rates. The solution was to address affective issues, such as perceived caring based on perception of continuous support and availability. Weems (2002) found that transforming traditional courses to be delivered on-line raised the quality of education, due to the development of on-line activities. While there appeared to be general satisfaction with distance education, it was difficult to more comprehensively assess overall effectiveness due to the array of on-line course formats. This array ran the gamut from self-directed (text-based with mail assignments) to highly structured (computer-based, assignment on-line). Only about one in four students felt distance education should replace face-to-face, expressing the opinion that it should serve as a substitute for text but not lecture. Students often misused on-line

course materials, however, ignoring active links and compiling hard copies of the materials, devaluing the materials' potential for active learning.

Hall and Keynes (1990) exhorted the values of cooperative learning in distance education, supporting an apprenticeship model that moves students from common misconceptions (this is called functional fixity). Taylor and Mohr (2001) focused on mathematical anxiety caused by poor teaching, lack of student understanding, and lack of subject relevance. They found support for student-centered learning initiated by solving real world problems. Important components for student success included using a text with more explicit content events and providing a more supportive instructional environment. Lawless (2000) found that student workload is among the most significant factors causing drop out in distance courses. Student attitude, motivation, and skill level all influence time spent studying and attitude about workload. This study includes a citation to the 32 Approaches to Study Inventory, a measure used to explore distance learning.

Research Findings

The following is a summary of findings from the 13 research articles. No attempt was made to measure the quality of the research studies, and qualitative and quantitative results are not distinguished.

Inman, Kerwin and Mayes (1999) found instructors who taught a distance course to have conflicting attitudes about distance education. While the instructors have positive attitudes about teaching subsequent distance courses, they have negative attitudes about the quality of distance education when compared to on-site courses. Student's attitudes about the quality of the distance education courses were influenced by several factors.

- Student attitude about quality of instruction was influenced by quality of instructor-generated material (55% of variance), quality of on-campus orientation session (9%), and perceived availability of instructor (5%)
- Student attitude about quality of the course was influenced most predominantly by course materials (59%). Their perception of how much is learned—which was reflected in improved critical thinking skills, understanding of the problem, increased subject knowledge, and the ability to relate the subject to their own lives—influenced student attitudes about the quality of the course only 4% of the time. (Other components of student attitudes about course quality did not rise to the level of statistical significance.)
- Leading factors that influenced student learning were quality of instructor-generated materials (33%), the quality of course materials (7%) and the amount of work (8%), with more work perceived as a positive influence.)

Overall, quality of instructional materials was the key issue, not the mode of technology. Students had positive attitudes about distance courses, and there was no significant difference in attitudes of students towards distance courses and on-site courses (Weems, 2002; Larson & Bruning, 1996; Lawless, 2000). Taylor and Mohr (2001) found that 77% of students in a distance course expressed improved confidence in math, and 92% expressed increased confidence for future courses. Their major course concern was 50% withdrawal rates, which were attributed to non-course factors such as work or family. (It is worth noting that, because of the timing of the evaluation, it is likely that only students who did not withdraw are represented in these figures.) While students

who completed the course had a positive view of the course, determining the attitudes of those withdrawing would provide essential information on the failure of distance courses for a large number of students.

Kubala (2000), Sullivan (2001) and Weems (2002) found that students' primary reasons for taking distance courses was flexibility in scheduling and convenience of place. Supporting flexibility, students indicated that they liked the asynchronous nature of distance courses. Because students lacked face-to-face interaction, only a small percentage favored on-line instruction over on-site (Sullivan, 2001). The anonymity of distance education provided a more positive learning environment for shy or quiet students, math-anxious male students, and females, who preferred the less masculine style of discourse that was not dominated by face-to-face, in-class confrontations (Sullivan, 2001; Smith, et.al., 2001; Taylor & Mohr, 2001). Students enrolled in distance education tended predominantly to be older, non-traditional students and females (Perez & Foshay, 2002).

Cognitive outcomes were harder to ascertain, and findings were more general. Two comparison studies found no significant difference in grades between on-line and on-site versions of a course (Szule, 1999; Weems, 2002). But Weems noted that test scores of on-line students did significantly decline through the semester. McCollum (1997) found that the on-line students scored 20% higher on exams then on-site students, attributing the difference to small groups and study groups formed on-line. Hall and Keynes (1990), however, found that 75% of students in a distance education course preferred individual to group work, while only 25% participated in self-help groups. Larson and Bruning (1996) found significant improvement in math placement scores for

college among students completing a high school distance education course, compared to those not taking the courses. This course used high school teachers as local facilitators. The facilitators expressed concern about the lack of flexibility in course pacing, which they felt led to negative attitudes on the part of students towards the distance instructor. But they did report that students had positive attitudes towards visual aspects of the course, including computer-generated representations of mathematical concepts, as well as real life demonstrations of practical applications.

Development issues were also addressed in some studies. While 94% of students in a distance education course had positive attitudes towards learning activities, excessive activities or excessive time required to complete an activity led to student shutdown (Lawless, 2000). Lawless found that 48% want to learn the subject, adopting a Holist (deep level processing) view that leads to a meaning-oriented approach where students spend considerable effort developing conceptual understanding. These students are willing to take on a heavier workload. On the other hand, 47% just want to pass the course, adopting an Atomistic (surface level processing) view, which leads to a reproducing-oriented approach and avoidance of workload. Students with this view are interested primarily in completing a task, not developing mastery or understanding. So it is important to analyze student work expectations and provide an environment where they can interact. Smith and colleagues (2001) call for three types of interaction: learner-content, learner-learner, and learner-instructor. Schmidt, Sullivan, & Hardy (1999) found the learner-learner interaction to be the most important in establishing a feeling of community. Sunderland (2002) espoused the use of e-mail to allow students a sense of community, immediacy of response, and anonymity.

Implications and Recommendations

This portion of the review combines implications of research with recommendations from both research and experiential based articles. The key recommendations are varied and in most cases only supported by three or fewer of the articles, making it difficult to identify any significant trends.

An underlying theme was the need for **professional development** of faculty engaged in distance education. Students are comfortable with less direct contact with the instructor; their concern is the quality of indirect interaction through materials. Instructors are not comfortable with less direct interaction, however; thus, they need professional development to help them change their role in teaching. Another recommendation is for frequent **formative course assessment** to help the instructor adapt to student needs. Kubala (1998) identifies 11 canons for distance education, components of which were supported by others:

- Provide a team for technical support – have a reliable technology infrastructure
- Build in collaborative work, debate, dialogue and conversational learning
- Require weekly quizzes
- Provide feedback within 24 hours
- Require higher cognitive skills
- Provide, and strictly follow, a syllabus
- Create a course forum for questions on course and concerns
- Assign students to write reaction papers using digital library and Internet research

- Avoid synchronous interaction, including chat room
- Provide global course plan before course starts

Of these the only recommendation directly contradicting those of others was the admonition to avoid synchronous interaction, such as chat rooms. Among others who offered recommendations, the need for a synchronous component to provide a learner-teacher interaction as well as learner-learner interaction was a common theme. Taylor and Mohr (2001) provided another extensive list of distance teaching principles that echoed Kubula.

Face-to-face meetings were supported by several articles; to provide an orientation for students to technology and course expectations, and to form community. It was recommended that this orientation should be recorded for later reference. One program professed the need for significant face-to-face interaction – at least monthly – both among students and between students and professor. The **development of community** was a common thread. The most difficult and important aspect of teaching on-line is not using technology but rather creating a sense of community and belonging. Females found the self-discipline and self-pacing required in distance learning to be negative aspects, and missed the social interaction and teamwork of on-site learning. But they are often place-bound by family and children, so distance education is a viable alternative. Distance education may also encourage ethnic diversity, especially if community is a focus. Recommendations for developing community include:

- Regional cohorts should meet virtually in smaller groups to form sense of community.
- Students should write reflective journals via e-mail that are shared with

the instructor.

- Programs should establish frequent faculty contacts via synchronous chat room to provide confidential and immediate feedback.
- The institution and the instructor should provide three support systems: multiple communities support (regional cohorts), multiple meeting spaces support (course management software such as WebCT), technical and interpersonal support.
- Courses should use threaded discussions where students respond to student postings to encourage a deeper discourse.
- When cooperative tasks are assigned, they should be divided into non-overlapping subtasks to encourage student interaction.
- Weekly projects should be assigned to promote peer interaction.
- Instructors should assign group bulletin boards to create small group interactions, then assign group leaders to summarize group input to the instructor.
- Instructor should provide supplements for students who missed classes.
- Programs should photograph all students and put pictures on-line.
- Instructors should make class participation a higher percentage of the grade.

While community is important, there are aspects of **anonymity** in distance education that have positive effects as well. The divested authority inherent in distance education encourages students to challenge the professor. The **one-on-one** nature of interaction is another positive aspect of distance education; such contacts may occur up to

three times more often than in an on-site course. Threaded on-line discussions engage students in more student-student and student-teacher interactions then in many on-site classrooms.

A strength of distance education is the ability to avail a **variety of resources** and experiences to the students, which would be difficult to do in an on-site course. Some recommendations for such activities include:

- Encouraging or requiring students to research projects on-line using virtual libraries.
- Providing students the opportunity to dialogue with on-line guest experts.
- Stressing and modeling national standards, such as the NCTM standards.

Assessment issues, especially testing, elicited varied views. Two articles insisted that exams be given on campus to control cheating. Another article argued that issues of cheating when testing at a distance should not be a concern, since distance courses must not be too place-based and future technological advances would solve many of the security concerns. It was argued that there is a strong need to align objectives with on-line assessments. These objectives need to be performance and competency-based.

Student support is a central issue, and there were several recommendations on how to achieve it in a distance course. Programs, faculty, or instructors should:

- Provide on-line virtual office hours at least 3 hours a week.
- Return assignments within a week.
- Make explicit the fact that distance courses require self-directed learning and self-initiative by students.
- Offer or require a computer skills assessment tool: self report inventory

(web version - Short, 2000).

- Provide a student manual.
- Provide a telephone help line.
- Structure lectures in 20 minute modules.
- Create CD-ROMs for video support.
- Limit enrollment to 30 students.
- Account for and respond to variations in student learning styles.
- For atomistic learners, place greater emphasis on explaining purpose and importance of activities in the learning process.
- Raise instructors' awareness of workload and establish length of time required to complete activities (based on analysis, not just professors' estimates).
- Create a virtual campus (for instance, via a Web portal) with links to accreditation, orientation, degree plans, academic advising, library, technical support, and on-line payment

High **drop out rates** in distance education can be managed by better **student recruitment**, including counseling potential enrollees on what to expect and more precisely analyzing the characteristics of successful distance learners and using those in the recruitment process. Offering a complete degree with financial and technical support will assist in retaining students. It is essential to evaluate the educational effectiveness of the course and adapt it as needed. This requires soliciting continuous feedback from students on the courses. In addition, user support is a key aspect of retaining students.

Recommendations for mode and technology included:

- Classes should use a scalable medium for a broad class of users.
- Classes should require minimum computer hardware; programs should configure CPU for student if providing laptops.
- Classes should reduce video when possible, while acknowledging that video introduction and conclusion to courses is essential.
- While video streaming is becoming more accessible, a minimal audio/visual requirement is creating a CD that supports the course.
- Shared files should be distributed in PDF format.
- Classes should provide text-based materials (rather than no text at all), which may be commercial, a collection of materials, or instructor created, to support the on-line materials.
- When held on-line, classes should use multimedia applications such as Real Player.

Recommendations for mathematics via distance included:

- Courses design should be based on learning theory (constructivist and didactic phenomenology), with math modeling as the course focus.
- Math education goals should reflect the real world: with problems that include context, use of authentic and professional tools such as mathematics software, be student centered and interactive, and intertwine subjects from multiple disciplines.

Some miscellaneous recommendations are that distance education programs should:

- Support faculty developing courses, to account for the extraordinary time

preparation distance education demands.

- Research courses, not students, while tracking student performance in subsequent courses.
- Establish remote sites with facilitators.

Conclusion

While there are a variety of experience-based recommendations on teaching via distance education, there is a lack of solid research on best practices. In addition, the myriad of approaches to distance education make it difficult to determine trends. The low cost and accessibility of computer-mediated methods make them a popular choice over satellite television, the choice of many colleges in the past. But there is a new approach that may challenge both: video conferencing. ACCLAIM is working on coalescing the extensive lists of recommendations in this review to determine a more focused set of tenets for ACCLAIM distance education courses. There is a lot of work to be done, not only by ACCLAIM, but in the larger realm of distance education.

References

Abrams, Gene & Haefner, Jeremy (1998). S.H.O.W.M.E.: Spearheading online work in mathematics education. *T H E Journal, 25*(10), 53-55

Carnevale, Dan & Olsen, Florence (2003). How to succeed in distance education. *Chronicle of Higher Education, 49*(40), A31-A33.

Charp, Sylvia (2000). Distance education. *T H E Journal, 27*(9), 10-12.

Chickering, Arthur & Gamson, Zelda. (1987, March). Seven principles for good practice in undergraduate education. *AAHE Bulletin*, 3-7.

Cooper, Linda (2000). Online courses. *T H E Journal, 27*(8), 86-92.

Cope, Eric W. & Suppes, Patrick (2002). Gifted students' individual differences in distance-learning computer-based calculus and linear algebra. *Instructional Science, 30*(2), 79-110.

Davies, Timothy Gray & Quick, Don (2001). Reducing distance through distance learning: the community college leadership doctoral program at Colorado State University. *Community College Journal of Research and Practice, 25*(8), 607-620.

Gilbert, Janna (1999). But where is the teacher? *Learning and Leading with Technology, 27*(2), 42-44.

Hall, James. (1990). Distance education: Reaching Out to Millions. *Change*, *22*(4), 48.

Heerema, Douglas L. & Rogers, Richard L (2001). Avoiding the quality/quantity trade-off in distance education. *T H E Journal, 29*(5), 14-19.

Hummel, Hans G.K. & Smit, Herjan (1996). Higher mathematics education at a distance: the use of computers at the Open University of the Netherlands. *Journal of*

Mathematics Science Teaching, 15(3), 249-265.

Inman, Elliot; Kerwin, Michael; & Mayes, Larry (1999). Instructor and student attitudes toward distance learning. *Community College Journal of Research and Practice, 23*(6), 581-591.

Kubala, Tom. (1998). Addressing student needs: Teaching on the internet. *T.H.E. Journal, 25*(8), 71-74.

Kubala, Tom (2000). Teaching community college faculty members on the internet. *Community College Journal of Research and Practice, 24*(5), 331-339.

Larson, Matthew R. & Bruning, Roger (1996). Participant perceptions of a collaborative satellite-based mathematics course. *The American Journal of Distance Education, 10*(1), 6-22.

Lawless, Clive (2000). Using learning activities in mathematics: workload and study time. *Studies in Higher Education, 25*(1), 97-112.

Lewis, Laurie: Snow, Kyle; Farris, Elizabeth; & Levin, Douglas. (1999). *Distance education at postsecondary education institutions, 1997-98* (NCES-2000-013). Washington, DC: National Center for Education Statistics. (ERIC Document Reproduction Service No. ED437879)

LePage, Denise. (1996). Distance learning complements a pre-service mathematics education model. *T H E Journal, 24*(1), 65-68

Merisotis, Jaime & Phipps, Ronald. (1999). What's the difference? Outcomes of distance vs. traditional classroom-based learning. *Change, 31*(2), 12-17.

McCollum, Kelly (1997). A professor divides his class in two to test value of on-line instruction. *The Chronicle of Higher Education, 43*(24), A23.

O'Malley, Claire & Scanlon, Eileen (1990). Computer-supported collaborative learning: problem solving and distance education. *Computers and Education, 15*(1-3), 127-136.

Perez, Stella & Foshay, Rob. (2002). Adding up the distance*:* can developmental studies work in a distance learning environment? *T H E Journal*,*29*(8), 16, 20-22, 24.

Russell, Thomas. (1999). *The no significant difference phenomenon.* Raleigh, NC: University of North Carolina Press.

Sbiek, Rose Mary & Foletta, Gina M (1995). Achieving standards in a fiber optic mathematics classroom. *Learning and Leading with Technology, 22*(8), 25-26, 28-29.

Schmidt, Kathy J, Sullivan, Michael J. & Hardy Darcy Walsh (1994). Teaching migrant students algebra by audioconference. *The American Journal of Distance Education, 8*(3), 51-63.

Serwatka, Judy A (2002). Improving student performance in distance learning courses. *T H E Journal*,*29*(9), 46-51.

Short, Nancy M (2000). Asynchronous distance education. *T H E Journal*,*28*(2), 56-64.

Smith, Glenn Gordon, Ferguson, David & Caris, Meike (2001*). T H E Journal, 28*(9), 18-25.

Sullivan, Patrick (2001). Gender differences and the online classroom: male and female college students evaluate their experiences. *Community College Journal of Research & Practice, 25*(10), 805–819.

Sunderland, Jane (2002). New communication practices, identity and the psychological

gap: the affective funtion of e-mail on a distance doctoral programme. *Studies in Higher Education, 27*(2), 233-246.

Szulc, Paul (1999). Reassessing the assessment of distance education courses. *T H E Journal, 27*(2), 70-74.

Taylor, Janet A. & Mohr, Joan (2001). Mathematics for math anxious students studying at a distance. *Journal of Developmental Education, 25*(1), 30-37.

Weems, Gail H (2002). Comparison of beginning algebra taught onsite versus online. *Journal of Developmental Education, 26*(1), 10-18.