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ABSTRACT

This paper discusses the use of technology in teaching and learning mathematics in community colleges. The first section addresses the current state of new technologies and learning in mathematics and statistics. The second section looks at the major trends in the coming years, specifically more reading, more writing, and less arithmetic. The third section lists the critical issues that need to be addressed. The fourth section outlines issues related to new teaching and learning environments, including a sound rationale for integrating technology, the need for greater integration of technology, issues for new users, how technology can help, and what you need to get started. (Contains 17 references.) (MES)

Mathematics and New Technologies Writing Team Report
5th Annual Teaching in the Community College Online Electronic Conference

Chair, Math Writing Team:
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KEY WORDS: teaching mathematics and statistics; technology integration; computers in education, undergraduate mathematics and statistics; active learning; multimedia in mathematics in mathematics education, technological reform in education

ABSTRACT:

The 5th Annual Teaching in the Community College Online Electronic Conference (TCC 2000) sponsored by Kapi'olani Community College, University of Hawaii, Honolulu, HI, Community College was held from April 12-14, 2000. University and community college educators from all over the world converged virtually to engage in synchronous and asynchronous discussion about teaching, learning and technology designed to help students experience greater success in the next millennium. Many presentations--invited, feature, and accepted papers--espoused the need for the increased use of technology as an electronic teaching assistant, more active learning, greater use of cooperative and collaborative learning techniques, and institutional tenacity in finding funds to support both teacher and student mastery of technological tools. This team report focuses on: (1) the current state of new technologies and learning; (2) the major trends in the coming years; and (3) the critical issues that need to be addressed in the area of undergraduate mathematics and statistics

1. THE CURRENT STATE OF NEW TECHNOLOGIES AND LEARNING IN MATHEMATICS AND STATISTICS

Current and emerging technologies are impacting education, at all levels, as never before. Active learning, cooperative learning, collaborative learning, standards-based curriculum, technological integration have become common catch phrases as we approach the 21st century. Mathematics and Statistics, each essential subject matter, and their instructional delivery have received great attention during an age of increasing prominence of technology and technological innovation. Students need to develop critical thinking skills, engage in proactive learning, demonstrate problem-solving skills, collaborate in active learning environments, and demonstrate competence in basic technological literacy. Incorporation of computer technology in instructional delivery of introductory statistics is not a guarantor that each of these necessary skills will be readily transferred to students. It is quite plausible, however, that a friendly merger between technology and basic mathematics and statistics instruction can do much to assist students in realization of these important goals.

Teaching mathematics and statistics at the secondary and post-secondary levels has undergone serious reform in the last decade, primarily as a result of the push to integrate technology into course delivery (Starkings, 1996). Not much has changed with respect to the need for students to actively engage in the process of learning a new language, as both mathematics and statistics represent subject matter replete with technical terms, yet practical applications. Now, as in the past, students continue to need encouragement to learn the languages of mathematics and statistics, associated terminology, and associated symbolism.

The push toward reform in mathematics and statistics instruction, alongside the explosion of instructional technology, has resulted in what appears to be a new tier in the hierarchy of basic quantitative literacy. This new level rests on the foundation that incorporation of technology in contemporary mathematics instruction is both timely and indispensable. By some accounts, graphing calculator and computer usage may even be appropriate replacement tiers for handheld computation; mastery of computational procedures, in the not too distant future, may be totally inappropriate as accessibility to powerful computer, mathematical and

statistical software increases (Jones, 1996). Quite commonplace is the theory which posits that multimedia techniques and the use of available technology in the mathematics classroom allow for the ideal visualization of difficult mathematical and statistical concepts, clear understanding, the exploration of mathematics, and the interpretation of statistical concepts (Darragh, 1996).

In discussing the role of technology in statistics education as early as junior high, Ben-Zvi & Friedlander (1996), reported that integration of computer technology in statistics instruction allows students to develop creative thinking skills, independence and cooperative learning skills with fellow students. Ward (1994) highlighted advantages of using computers in introductory statistics instruction with high school students. Rossman (1996) espoused a workshop approach to college-level statistics instruction in which technology should be incorporated as an active learning tool. Rossman's workshop approach, which abandons the traditional lecture format, allows students to collaborate on activities, thereby enabling them to discover statistical concepts, explore statistical principles, and apply statistical techniques. Weiss (1996) also discussed strategies for using technology in introductory statistics courses at the undergraduate level.

2. THE MAJOR TRENDS IN THE COMING YEARS

Statements of standards from organizations such as the National Council of Teachers of Mathematics (NCTM) continue to call for greater integration of technology in traditional mathematics instruction. For example, NCTM (1998) recommendations include the following:

The widespread impact of technology on nearly every aspect of our lives requires changes in the content and nature of school mathematics program. In keeping with these changes, students should be able to use calculators and computers to investigate mathematics concepts and increase their mathematical understanding.

* MORE READING

It Is important to encourage students to learn the language of mathematics and statistics, well in advance of any 'plug and chug' discourse, regardless of whether that 'plug and chug' is demonstrated by handheld computation, calculator-assisted manipulations (e.g., graphing calculator), or via the personal computer. Students must realize that the ability to interpret any resulting output or numerical solution is severely hampered in the absence of their mastery of the languages, terminology, and semantics of mathematics and statistics. When adopting this teaching perspective, it should become clear to students early in the course that 'contextual interpretations' as well as a 'layman's interpretation' are relevant to practically every mathematical problem. Even a cursory glance may be given to 'interpreting' the data, for those problems that involve purely basic algebra or descriptive statistics. As students actively learn mathematics and statistics, a respect for the language can be more readily cultivated; usage of formal jargon, alongside the 'everyday' English expression or equivalent should be constant - by both instructor and student.

* MORE WRITING

Incorporation of technology in teaching undergraduate mathematics and statistics potentially downplays the need for algebraic tedium in repetitive computations. In fact, the mechanics of mathematics, in and of itself, is relegated a less visible role in course instruction. Rather than concentrating on plug and chug of number into repetitive algebraic algorithms, those who teach with technology prefer to stress 'munch' - food for thought. Validation of a student's competence in addition, subtraction, multiplication, and division is deemed much less important than refining the ability to make sense of the problem being solved or data being analyzed. Generally, the integration of technology in course delivery frees up substantial time to engage students in the non-passive processes of conceptual understanding in mathematics and experimental design, data collection, and subsequent interpretation via verbal or written reports in statistics. Admittedly, some turbulence may be encountered, due to varying levels of student computer literacy, as a technologically enhanced course in mathematics or statistics gets underway. Once that turbulence has dissipated, however, students can take advantage of more numerable opportunities to understand the meaning of mathematics and statistics, rather than practice algebraic proficiency.

* LESS ARITHMETIC

Therein lies the primary dilemma - finding the point of balance between algebraic tedium (plug and chug) and graphing calculator or computer utilization (plug) in the undergraduate mathematics curriculum. For most mathematical and statistical computations, instructor modeling of handheld mechanics once, and at most twice, seems fairly reasonable. Beyond that, students can be encouraged to practice problem solving as many 'algebra exercises' as they are so inclined by handheld mechanics. As the proliferation in computer availability and use increases, however, allotting multiple class periods to practice sessions in algebraic 'plug and chug' proficiency seems innately anachronistic. Students who wish to perfect greater skill and acumen for handheld computation need not be discouraged; their queries should simply be addressed via follow-up via office hours - real time or virtual, depending on institutional setting. Nonetheless, a computer is no smarter than the individual sitting in front of it. A computer can certainly perform an algebraic algorithm in record time; however, it makes no contribution to resulting interpretations of data. Provided students fail to develop a fundamental understanding of mathematical and statistical procedures, use of the calculator or computer may certainly result in the personification of what has been coined as a catch phrase for misuse of computers - GIGO (garbage in, garbage out). In recent years, this term has been adapted to refer to those individuals who trust calculators and computer results religiously - GIGO (garbage in, gospel out).

Those who favor a more rigorous presentation of mathematical curricula cite 'working out' the problems as essential. These individuals support procedural competency via demonstrated computational ability and even contend that a course devoid of mechanical proficiency is one which can and probably will render dangerous students - students who can push calculator keys and perform computer keystrokes, but who know little, if anything, about mathematics and statistics. This cohort cites the more recent use of the acronym GIGO - garbage in, gospel out. Still, while rigor in mathematical derivations may be appropriate at the graduate level, students enrolled in a first year introductory mathematics or statistics course are better served by focus on concepts, rather than algorithms and repetitive 'plug and chug' of numbers into mathematical and statistical formulae.

3. THE CRITICAL ISSUES THAT NEED TO BE ADDRESSED

* Technology--- Will it replace us? (http://www.nea.org/he/webppt/cgu2/webever.html)
* Keeping community college students (traditional, nontraditional, returning, adult, transfer) on the same page as elementary and middle school students, in not high school students, with respect to technology exposure
* Integrating Technology as a teaching and learning tool in the classroom environment
* Infusing critical thinking skills into the mathematics curriculum
* Avoidance of negative correlation between scores measuring technological proficiency and mathematical literacy
* Literal and literacy gap among faculty and students alike in community college teaching and learning environments
* Equivalence between face to face (F2F) mathematics instruction and online, distance learning mathematics instruction (See article by team member, Dale Mueller, http://www.love2learn.com/tcc99.html)
* Back to the Basics or Forward to the Basics--Which Philosophy Should We Embrace? (NCTM, 1999)
* Getting those darned mathematical and statistical symbols online in a universally acceptable and accessible format.
* Whiteboards, chat rooms, bulletin boards - how do you effectively explain mathematics and mathematical reasoning online?
* Testing traditional mathematics (pen and paper work) in nontraditional environments (online, distance learning)
* Which software?
* Quantitative literacy, technical literacy-what are the answers? Do any of us really know the questions as the role of technology in instruction continues to evolve?
* The Future of Technology in Mathematics Instruction
* Are we sure we're not just teaching computers? Is this what we mean by the NEW MATH?

* The New Math in a technological environment -- more reading, more writing, less arithmetic.
* Research, research, research - getting it to those people in the trenches - community college faculty
* Classroom research - what are our students telling us about the use of technology
* Maintaining quality in the mathematics curriculum with the value-added technological component to instruction
* Seamless integration of technology with mathematics instruction - two courses or one?
* How to best integrating content, active and collaborative learning, and technology
* Transforming the professorate, transforming the way we teach
* Instructor preparedness - finding the time for professional development for community college faculty
* The Paradigm Shift - Learning Centered Instructional Environments

4. New Teaching and Learning Environments - Getting in the Game, New Users, Traditional Classrooms and Technology

I. Sound Rationale for integrating Technology

A. Why Teach This Way? (Grounded in Theory)
The Seven Principles for Good Practice in Undergraduate Education (Arthur W. Chickering and Zelda F. Gamson, 1987, AAHE)

1. Encourages student-faculty contact
2. Encourages cooperation among students
3. Encourages active learning
4. Gives prompt feedback
5. Emphasizes time on task
6. Communicates high expectations
7. Respects diverse talents and ways of learning

B. Why Teach This Way? (Grounded in Practice, Empirical Data)
1. Students report enjoying it, and have begun to demand it for articulation success.
2. Students have different learning styles; multiple pathways through learning materials

C. Why Teach This Way? (Grounded in Reality)
1. The new literacy for the 21st century and beyond is clearly the ability to utilize appropriate technological tools in an information society.
2. The personal computer and associated technological innovations - the Internet, E-mail, word processing packages, and personal web sites - have become commonplace.
3. The core skill for today's society is not foraging for data, but filtering a plethora of incoming information (Dede, 1992).

II. Need for greater integration of technology
A. Societal demands
B. Employment need for more technologically literate workers
C. Increasingly important role in work and personal lives
D. Students are learning in grade schools, pre-schools
E. New methods of communication
F. Form of instructional delivery is changing
G. Dissemination of basic information
H. Finite resources of institutions (distance learning)
I. Survival
J. Efficiency; time, accessibility

III. Issues for new users
A. Relative to Self
1. Time Pressure
2. Rapidly changing (hitting a moving target)

3. Constant struggle to remain current
4. State-of-the-art equipment
5. Barriers between faculty and technology support
6. Learning the basics/core competency
* PC use
* Word processing
* E-Mail
* Internet
* Mailing List serve/threaded discussions
* Accessing and Evaluating Web Sites
7. Maintaining contemporary skills
8. Self directed learning of new skills
9. Applying technology
10. Gap between need and ability
11. Affordability
12. Training
13. Curriculum control
14. Curriculum redesign
15. Accessibility
16. Appropriate instructional design/incorporation of technology
17. Stability of technology
18. Evaluation

B. Relative to students
1. Are students ready for this?
2. Is this a course in and of itself?
3. More confusing?
4. Affordability
5. Basic computer skills
6. Readiness level
7. Training
8. Relevance in the classroom
9. Cooperative learning
10. Distance Learning
11. Self-paced learning
12. Accessibility
13. Equity
14. Stability of technology
15. Coverage of core content material
16. Barrier to learning or enabler
17. Not for all students
18. Anxiety level (especially older, computer phobic students)
19. Compatibility (Are we really all on the same page?)
20. What should I get?
21. Server downtime
22. New frontier in learning
23. Lost in cyberspace

C. Relative to institution (administration)

1. Wiring the campus
2. Affordability
3. Huge investment of campus resources
4. Server problems
5. Maintenance
6. Sustainability

7. FTE performance based funding
8. Which system?
9. Staying current and up to date
10. Articulation process with colleges and universities
11. Curriculum redesign
12. Strategic Planning

IV. How technology can help

1. Communication
2. Creative expression
3. Data Handling
4. Filtering information
5. Efficient manipulation of information
6. Analyze information
7. Synthesize information
8. Reformulate knowledge
9. Sharing ideas (electronically)
10. Visual learning (multiple pathways through learning materials)
11. Increasing important communication tool
12. Alternative learning environment
13. Reach more students simultaneously
14. Extended opportunity to interact with students
15. One on one interaction
16. Electronic transcript
17. Precise information (time saver on lecture chalk and talk, note taking)
18. New forum for class interaction
19. New ways of teaching and learning

V. Getting Started (What do you Need)

A. Hardware/Software
1. A computer (at work and at home)
2. Modem (faster the modem, faster your connection, faster data acquisition and transfer)
3. Current version of Web browser (common Netscape or Internet)
4. Word processor
5. Web Page Authoring Tool or Program
6. Space to post your class web site (institution's server, ISP account, your hard drive)

B. "Indispensables"
1. An experienced friend or mentor who will help you
2. A positive can do attitude
3. An understanding that you can never learn it all!!!!!!
4. Courage to ask for help
5. Yearning for lifelong learning
6. Support group

C. Now What? Ready Set Go! Implementation
1. Basic Understanding of how to use your computer, word processor, browser, simple web design
2. Databank of electronic or hard copy resources
3. Subscription to a good quality technology journal
4. Workable Plan for curriculum redesign
5. Evaluation System

5. CONCLUSION

Use of instructional technology portends to be much more than a fad. The emergence of computers and associated technological innovations as increasingly pervasive forms of communication and data transfer cannot be overlooked. Technological literacy can assist students in preparing for higher education, as many universities now require that students 'come to campuses with a computer, be reasonably computer literate, and be able to interact with professors 'on-line'. There will be increasing tension between those who are comfortable using technology and those who are not (Burrill, 1996). Computers can and should be used to facilitate student learning in the instructional delivery of undergraduate mathematics and statistics; an invaluable help is provided through the use of these robot-like teaching assistants. It is true, however, that great caution should be exercised with respect to utilization of these technological devices. Professors who successfully incorporate computers in the instructional delivery of mathematics curricula do so with one important frame of reference - computers are not substitute teachers. While working in more depth with content, students are able to move beyond rote memorization to application and analysis of information, thereby epitomizing the adage that the beauty of education is in its application (Dockstader, 1996). Integrating software and the Internet will continue to expand the scope of mathematics and statistics course work in the coming years (King, 1998).

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I. Sound Rationale for integrating Technology

A. Why Teach This Way? (Grounded in Theory)
The Seven Principles for Good Practice in Undergraduate Education (Arthur W. Chickering and Zelda F. Gamson, 1987, AAHE)

1. Encourages student-faculty contact
2. Encourages cooperation among students
3. Encourages active learning
4. Gives prompt feedback
5. Emphasizes time on task
6. Communicates high expectations
7. Respects diverse talents and ways of learning

B. Why Teach This Way? (Grounded in Practice, Empirical Data)
1. Students report enjoying it, and have begun to demand it for articulation success.
2. Students have different learning styles; multiple pathways through learning materials

C. Why Teach This Way? (Grounded in Reality)
1. The new literacy for the 21st century and beyond is clearly the ability to utilize appropriate technological tools in an information society.
2. The personal computer and associated technological innovations - the Internet, E-mail, word processing packages, and personal web sites - have become commonplace.
3. The core skill for today's society is not foraging for data, but filtering a plethora of incoming information (Dede, 1992).

II. Need for greater integration of technology
A. Societal demands
B. Employment need for more technologically literate workers
C. Increasingly important role in work and personal lives
D. Students are learning in grade schools, pre-schools
E. New methods of communication
F. Form of instructional delivery is changing
G. Dissemination of basic information
H. Finite resources of institutions (distance learning)
I. Survival
J. Efficiency; time, accessibility

III. Issues for new users
A. Relative to Self
1. Time Pressure
2. Rapidly changing (hitting a moving target)

3. Constant struggle to remain current
4. State-of-the-art equipment
5. Barriers between faculty and technology support
6. Learning the basics/core competency
* PC use
* Word processing
* E-Mail
* Internet
* Mailing List serve/threaded discussions
* Accessing and Evaluating Web Sites
7. Maintaining contemporary skills
8. Self directed learning of new skills
9. Applying technology
10. Gap between need and ability
11. Affordability
12. Training
13. Curriculum control
14. Curriculum redesign
15. Accessibility
16. Appropriate instructional design/incorporation of technology
17. Stability of technology
18. Evaluation

B. Relative to students
1. Are students ready for this?
2. Is this a course in and of itself?
3. More confusing?
4. Affordability
5. Basic computer skills
6. Readiness level
7. Training
8. Relevance in the classroom
9. Cooperative learning
10. Distance Learning
11. Self-paced learning
12. Accessibility
13. Equity
14. Stability of technology
15. Coverage of core content material
16. Barrier to learning or enabler
17. Not for all students
18. Anxiety level (especially older, computer phobic students)
19. Compatibility (Are we really all on the same page?)
20. What should I get?
21. Server downtime
22. New frontier in learning
23. Lost in cyberspace

C. Relative to institution (administration)

1. Wiring the campus
2. Affordability
3. Huge investment of campus resources
4. Server problems
5. Maintenance
6. Sustainability

7. FTE performance based funding
8. Which system?
9. Staying current and up to date
10. Articulation process with colleges and universities
11. Curriculum redesign
12. Strategic Planning

IV. How technology can help

1. Communication
2. Creative expression
3. Data Handling
4. Filtering information
5. Efficient manipulation of information
6. Analyze information
7. Synthesize information
8. Reformulate knowledge
9. Sharing ideas (electronically)
10. Visual learning (multiple pathways through learning materials)
11. Increasing important communication tool
12. Alternative learning environment
13. Reach more students simultaneously
14. Extended opportunity to interact with students
15. One on one interaction
16. Electronic transcript
17. Precise information (time saver on lecture chalk and talk, note taking)
18. New forum for class interaction
19. New ways of teaching and learning

V. Getting Started (What do you Need)

A. Hardware/Software
1. A computer (at work and at home)
2. Modem (faster the modem, faster your connection, faster data acquisition and transfer)
3. Current version of Web browser (common Netscape or Internet)
4. Word processor
5. Web Page Authoring Tool or Program
6. Space to post your class web site (institution's server, ISP account, your hard drive)

B. "Indispensables"
1. An experienced friend or mentor who will help you
2. A positive can do attitude
3. An understanding that you can never learn it all!!!!!!
4. Courage to ask for help
5. Yearning for lifelong learning
6. Support group

C. Now What? Ready Set Go! Implementation
1. Basic Understanding of how to use your computer, word processor, browser, simple web design
2. Databank of electronic or hard copy resources
3. Subscription to a good quality technology journal
4. Workable Plan for curriculum redesign
5. Evaluation System

5. CONCLUSION

Use of instructional technology portends to be much more than a fad. The emergence of computers and associated technological innovations as increasingly pervasive forms of communication and data transfer cannot be overlooked. Technological literacy can assist students in preparing for higher education, as many universities now require that students 'come to campuses with a computer, be reasonably computer literate, and be able to interact with professors 'on-line'. There will be increasing tension between those who are comfortable using technology and those who are not (Burrill, 1996). Computers can and should be used to facilitate student learning in the instructional delivery of undergraduate mathematics and statistics; an invaluable help is provided through the use of these robot-like teaching assistants. It is true, however, that great caution should be exercised with respect to utilization of these technological devices. Professors who successfully incorporate computers in the instructional delivery of mathematics curricula do so with one important frame of reference - computers are not substitute teachers. While working in more depth with content, students are able to move beyond rote memorization to application and analysis of information, thereby epitomizing the adage that the beauty of education is in its application (Dockstader, 1996). Integrating software and the Internet will continue to expand the scope of mathematics and statistics course work in the coming years (King, 1998).

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