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Calculators in middle school mathematics classrooms

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Abstract

Calculators can be a catalyst for all mathematical learning. Arithmetic skills are necessary life tools. Doing mental math requires basic facts mastery with estimation skills. Using a calculator successfully and evaluating the answer requires an understanding of the necessary arithmetic processes and the ability to identify a reasonable solution.

Like all technology available in the K-12 school setting, calculators should be viewed as tools to facilitate learning and logical reasoning. Students need to be prepared for the jobs of the future, many of which occupations have not yet even been created. The motivation for learning any skill in life is that skill's eventual application. Using calculators will allow children to learn how to problem solve, a critical aptitude for success in these novel, and as yet, uncreated vocations. Calculators need to move past the "check problems" tool and onto the new role of problem-solver (Schmidt, 1997).

CALCULATORS IN MIDDLE SCHOOL MATHEMATIC CLASSROOMS

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CHAPTER I

Introduction

Throughout history, people have viewed change in mathematics negatively. In ancient times, realistic representations of goods were used when tallying inventory. Using abstract symbols for the same purpose was a horrific idea and took many years to be accepted. These abstract symbols influenced all written language throughout the years which then led to people in the Middle Ages spelling out their numbers in Latin to do arithmetic, never considering the ease of Arabic numbers that had been discovered during the Crusades. By the 1700's Arabic numerals became acceptable for daily use.

In American classrooms, students first ciphered their mathematics mentally; later personal chalk boards were used to check mental ciphering. When pencil-and-paper calculations were introduced, parents and businesses complained that schools were not training students well because the emphasis on mental calculations was decreased. In 1978 the National Council for the Teachers of Mathematics (NCTM) recommended that calculators be made an integral part of the educational process in math classrooms.

The complaint that math teachers are not training students is still being made. In the opinion of non-educators, children should do many drill-and-practice

exercises using arithmetic skills to get them ready for jobs after graduation, not "cheat" by using calculators to find answers. However it is estimated that students in grades kindergarten through eight spend perhaps as much as ninety percent of school mathematics time in drill-and-practice exercises (Burns, 1992).

Research Questions

1. Do math classrooms accurately reflect important job skills needed by students in the future by not infusing calculators into the curriculum? 2. Can calculator use impede learning? 3. What are the educational benefits for students and teachers when calculators are used? 4. What problems are to be considered when integrating calculators into mathematics instruction?

Terms

·behaviorist: a person who believes that learning is a change in the probability of a particular behavior occurring in a particular situation.

·collaborative work: small group of students work towards a common goal, but each student has a separate job within the group.

·constructivist: a person who believes that learning is a change in meaning constructed by individual experience.

·essential learnings: educational goals for students set by the school district, teachers, and parents.

CHAPTER II

Literature Review

Teachers and schools must prepare their clients and themselves for the world of work, which includes the use of technology (Schmitt, 1996). Adults recognize calculators as indispensable tools in today's world (Bitter & Hatfield, 1993). When adults review the computing methodology they use most often, adults are surprised to realize they use calculators and mental estimation (Burns, 1992; Cruikshank & Sheffield, 1988).

Basic arithmetic needed in real life require choosing the operation or operations, choosing the numbers to use, performing the calculation using the best method for the situation, evaluating the reasonableness of the answer, and deciding what to do with the result. The use of calculators and computers with estimation and mental math skills is essential to job skills while doing arithmetic longhand is losing importance every day (Cruikshank & Sheffield, 1988). Therefore, it is crucial to incorporate technology into the classroom to assist with tedious arithmetic practice, not just to give students some exposure to calculators (Schmitt, 1996).

Unforunately, even with demonstrated mastery of arithmetic concepts, many children cannot apply those concepts to even the simplest problem (Burns, 1992).

Traditional algorithmic practice works on skills in isolation. Children must be able to utilize the various arithmetic skills integral to problem-solving situations. "Shopkeeper skills", paper-and-pencil practice of skills in isolation, do a disservice to students who must problem-solve when they enter the work force (Cruikshank & Sheffield, 1988). The educational populace needs to decide for itself whether calculators make sense for its students, school, and community , in light of the district's essential learnings (Hess & McNergney, 1998).

An over-reliance on calculators can cause a serious drawback to learning unless students understand the concepts of rational and irrational numbers and their properties (Belsom, 1995). Dunham & Dick (1994) noted a study by Becker that showed graphing calculators did not always improve students' understanding of certain concepts when the tools were introduced before the skills were practiced manually. Critics contend that introducing the calculator too early will hinder the development of students' mathematical ability. Bitter and Hatfield (1993) quote studies performed by Fuys & Tischler, Rudnick & Krulik, and Suydam that demonstrate that using calculators at every grade level has no negative effect on students' skills or achievement.

On the other hand, the National Council of Teachers of Mathematics points out that if students have not been successful in mastering basic computational skills with years of arithmetic worksheet practice, the continuation of rote practice will not help. Capable educators know that if one approach or methodology is not successful in the classroom, one must try another until a successful method of instruction is found which increases understanding by students. Also, using calculators in new problem-solving situations may give the opportunity for students to see the connection to previously practiced skills and to give them opportunities to perfect these skills in real-world applications (National Council of Teachers of Mathematics, 1989).

Educational approaches can impede learning, even when calculators are a part of the instructional process. For behaviorist teachers, calculators should strictly be used for yes-or-no answers or checking students' work. In this approach, the problem-solving process is not engaged. In a constructivist perspective, however, calculators are used to assist students as they solve problems and allow increasingly complex assignments to be inserted into the curriculum sooner, becoming self-directed learners which the teacher and calculator are resources for the learners (Cruikshank & Sheffield, 1988).

Programs such as the Middle School Teachers Enhancement Project (MSTEP) were developed to model many of the instructional techniques recommended by the National Council of Teachers of Mathematics to improve calculator usage, increase student learning, and reform classroom instruction (Schmitt, 1996). Change in teacher attitudes after MSTEP included allowing students to struggle, introducing students to more advanced mathematics prior to being proficient in basic skills, using calculators in the classroom, and withholding correction of incorrect responses to allow students to correct themselves. This successful program caused a change in teachers' attitudes which caused a dramatic shift to a constructivist approach of instruction, again aligning with the National Council of Teachers of Mathematics's (1989) Standards.

The educational benefits for students and teachers when calculators are used are diverse. Middle school students, due to their maturing bodies and growth spurts, learn best when doing hands-on activities in tactile, auditory, and visual instructions (National Council of Teachers of Mathematics, 1989). Work should be varied among small groups, large groups, or whole class instruction, depending on the educational goals for the particular lesson or unit. In this manner, students become active learners challenged by new

situations, and they create new connections from previous knowledge to new learning.

Calculators enable children to explore number ideas and investigate realistic applications (Billstein, Libeskind, & Lott, 1993). Estimation and mental math skills take on increased importance with calculator use, two of the best means of developing a child's understanding of numbers and their properties (Bitter & Hatfield, 1993; Burns, 1992). For students, Belsom (1995) notes that calculator usage makes learning more interesting, teaches a number of extremely valuable and useful skills, and encourages worthwhile mathematical activity in the classroom. In DeVaney's (1996) study , he noted a statistical link between calculator usage and eighth grade students' achievements in geometry in Mississippi.

Students who feel empowered by calculators are more likely to be successful in mathematics (Dunham & Dick, 1994). Low achievers and/or handicapped students find motivation to contribute to the problem-solving process when calculators are integrated in the curriculum. This usage narrows the gap in mathematical performance between special education students and the rest of the student population (Bitter & Hatfield, 1993).

Gender can make a difference in the success in learning with calculators. In Bitter and Hatfield's

(1993) study , girls reported feeling more confident and smarter when using a calculator. In another study , when students were using both regular calculators with last-entry-or-result (LER) display or multi-line-multi-operation (MLMO), girls consistently outscored boys (Owens, 1995).

Students also ascertain that each problem can have several approaches to solve, each one correct in its own methodology (Dunham & Dick, 1994). Cruikshank and Sheffield (1988) note that calculators can lessen math anxiety, making class more enjoyable. The more success students have performing computations in mathematics, the more positive the students' attitudes will be towards mathematics, which should increase the likelihood that students will take additional and more challenging math classes in high school and beyond (DeVaney, 1996; Dunham & Dick, 1994).

Calculators do not replace the need to learn basic facts, to compute mentally, or to do reasonable paper-and-pencil computation for either gender. Even after using calculators for two years, teachers saw the increasing need for estimation and mental calculation skills (Schmidt, 1997). These machines allow schools to move away from "answer-oriented" instruction to a more student-led education, focusing on the real-life applications of mathematics (Bitter & Hatfield, 1993).

Further, research performed by the National Research Council in 1989 demonstrated that students who use calculators leave high school with enhanced problem-solving skills and upgraded attitudes towards mathematics in general (Lehman, 1994). Farrell (cited in Dunham & Dick 1994) found that students become more active in classrooms when using technology, with more collaborative work, investigations, explorations, and problem-solving consistently occurring in math classes.

Calculators are ladders to learning, not a prop for a show. Technology is a part of the instruction, not a replacement for the instructor. Consequently, there are many considerations when integrating calculators into mathematics instruction.

Teachers need to ascertain that all students have access to a calculator whose functions meet the tasks needed to complete work for both in the classroom and at home (Billstein, Libeskind, & Lott, 1993; National Council of Teachers of Mathematics, 1989). Parental concerns that students might become dependent upon calculators will need to be addressed. The public needs to be informed of calculator usage, its role with the school's essential learnings, and the reform of the mathematics curriculum. The widespread availability of calculators and their effect on math remains a political hot potato, mired in emotional debates (Oldknow, 1996).

The slowly increasing use of calculators in teaching mathematics include a number of issues concerning both teaching and learning. In fact, the National Council of Teachers of Mathematics (1989) recommend that appropriate calculators should be available to all students at all times, including graphing calculators (Dunham & Dick, 1994). Children should be encouraged to decide when calculator usage is appropriate and when it would be easier and simpler to solve the give problems mentally (Cruikshank & Sheffield, 1988). Teachers also need to consider what kind of calculator would be the better choice for the lesson-either a last-entry-or-result (LER) display or a multi-line-multi-operation (MLMO) calculator. Learning to use either calculator effectively demands time, effort, and the constant revamping of the instructional approach by the instructor and school system.

Even when teachers are fully trained and students each have a calculator, difficulties can still arise. In a recent paper, after training teachers for twelve hours before school began and after providing every class with enough calculators for every student and an overhead projector calculator for the teacher, researchers found that student calculators were only used approximately twenty-five percent of the time and the overhead calculator was used less that one-tenth of one percent

of the class time (Huang & Waxman, 1994). Interestingly, when the students were surveyed, about fifty percent never used the calculators at all while nine percent used the calculators all of the time (Huang & Waxman, 1994). These findings indicate that just providing the technology instruments is not enough; both teachers and students need training to effectively use the devices along with additional training for teachers throughout the school year. Inservicing with follow-up sessions can make teacher feel empowered about making calculators an integral part of the mathematics curriculum (Schmidt, 1997).

Attitudes of teachers can greatly affect the successful use of calculators in math classrooms. Schmidt (1997) quotes several studies that indicate that teachers' beliefs about mathematics play a significant role in their behaviors during instruction. Many educators are aware that calculators need to be integrated throughout the curriculum, but they may not know how to meet the objectives (Schmidt, 1995). If a teacher understands how a calculator works and learns how to use it as another teaching tool, the calculator becomes more powerful (Schmitt, 1996). Again, this understanding involves additional training.

This lack of inservice and training has been indicated as one of the main reasons calculator

integration has been hindered (Schmidt, 1997). Teachers need instruction in using calculators in math classes. Instructors also need to keep abreast of research results regarding student performance and affective variables associated with calculator use (Bitter & Hatfield, 1993). Many conferences and teacher preparation courses now devote sessions to this hand-held technology, and some calculator manufacturers schedule teacher training sessions throughout the United States (Oldknow, 1996).

Educators need to understand that to incorporate calculators into the classroom through a combination of technology use and changes in curriculum and instruction (Dunham & Dick, 1994). One way to increase teachers' willingness to infuse calculators into the curriculum is for the schools to provide the necessary support teachers need, such as inservice days and substitute teachers allotments. Other incentives, like merit pay and national certification, may also need to be developed.

Textbooks and supplementary materials have caused additional problems when bringing calculators into the classroom on a permanent basis. Textbook publishers are slowly inseminating the many facets of calculator usage throughout the textbooks, instead of isolating those skills at the end of a chapter, having only a couple of

exercises designated as "calculator" problems, or writing "calculator skills" worksheets (Reys & Smith, 1994). Both teachers and book publishers need to develop assessment methods that accurately reflect the usage of calculators as essential tools, rather than an instrument to compute the correct answer. Unfortunately, updates in curriculum and manipulatives only occur every few years when a new textbook series is adopted or a teaching innovation is inserviced district-wide (Schmidt, 1995).

Monetary difficulties are another difficulty to overcome when bringing calculators into the classroom (Hess & McNergney, 1998). Where two or more classroom must share one set of calculators , it becomes even more difficult to use technological tools to explore mathematics (Lehman, 1994). The perspective of some administrators is that sets of calculators should be paid out of a teacher's budget, instead of viewing these tools as technology, thereby qualifying for a slice of the school's technology budget. It should be a bipartisan effort of teachers and administrators to decide: what kind of technology should be purchased; how extensive the infusion of calculators should be throughout the school system; and how much time and money should be devoted to training teachers in using the new purchases (Hess & McNergney, 1998).

CHAPTER III

Conclusion

Calculators can be a catalyst for all mathematical learning. Arithmetic skills are necessary life tools. Doing mental math requires basic facts mastery with estimation skills. Using a calculator successfully and evaluating the answer requires an understanding of the necessary arithmetic processes and the ability to identify a reasonable solution. As noted by Cruikshank and Sheffield (1992):

> The availability of technology offers everyone the opportunity to emphasize the thinking, reasoning, and problem-solving and to de-emphasize the rote memorization that so often characterized the teaching of basic facts and algorithms. Using a calculator...to assist with computation should be for a mathematician what using a word processor is for a writer. (p. 12)

Like all technology available in the K-12 school setting, calculators should be viewed as tools to facilitate learning and logical reasoning. Students need to be prepared for the jobs of the future, many of which occupations have not yet even been created. The motivation for learning any skill in life is that skill's eventual application. Using calculators will allow children to learn how to problem solve, a critical

aptitude for success in these novel, and as yet, uncreated vocations. Calculators need to move past the "check problems" tool and onto the new role of problem-solver (Schmidt, 1997).

Critics of students using calculators imply that arithmetic skills are no longer taught in schools. Teachers know that these skills still receive instruction but are less practiced because calculators give a handy alternative to the boring repetition of pages of drill-and-practice worksheets. Still the very low percentage of calculator use suggests that integrating technology into middle school mathematics classrooms has fallen short of expectations so far. Fortunately, the trend for calculator use is rising (Reys & Smith, 1994).

Calculators have become a commonplace tool. They seem to promote self-confidence and mathematical performance. Back in 1975, the National Advisory Committee on Mathematics Education (NACOME) first recommended the use of calculators no later than by eighth grade (Reys & Smith, 1994). Since that recommendation, the use of calculators has been endorsed by most major educational organizations, including the National Council for the Teachers of Mathematics (National Council of Teachers of Mathematics), the National Science Board Commission on Precollege

Education in Mathematics, Science, and Technology, and the National Education Association (NEA). Calculators are here, and both students and teachers like and use them. The task at hand is to accommodate calculators into the curriculum, both in the classroom and at the curriculum development level.

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