DOCUMENT RESUME

ED 420 500 SE 061 490

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TITLE Mathematics Reform: A Call for Balance.
PUB DATE 1998-03-24
NOTE 13p.
PUB TYPE Reports - Descriptive (141)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Educational Change; Elementary Secondary Education; *Mathematics Curriculum; *Mathematics Education; *Mathematics History; Standards; Teaching Methods

ABSTRACT

This document provides a history of mathematics education and the reforms that have taken place in the past in order to understand current reform. Information is presented on setting the stage for current reform efforts and issues. Reviewing mathematics education history is necessary when seeking possible solutions that are realistic for the success of future mathematics education. A balanced approach is the key to mathematics education reform. Contains 13 references. (ASK)

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Mathematics Reform:

A Call for Balance

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March 24, 1998

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"When groups of adults get together to fix education, the result is often one loud voice pitted against another loud voice" (Pipho, 1997, p.261). Nearly everyone has seen that most people's convictions become very intense when the topic of education is being discussed. These convictions are understandable because education is a part of every one of our lives and plays a vital role in the development of our nation's future. This general concern for education policy also explains the current debate over the reforms taking place in mathematics. Like many of the disciplines in public education, mathematics has come under intense review over the past ten years, causing a reform that is being championed and criticized by many. To understand this current reform, one must have some understanding of the history of math education and the reforms that have taken place in the past. There are also many issues of debate in the current reform that must be taken into consideration. Only then can we look at possible solutions that are realistic for the success of future math education and see that a balanced approach is the key.

History of Math Education and Reform

The main theory of education through the eighteenth and nineteenth centuries stressed mental discipline. This came in the forms of rote memorization and drill. A teacher dispensed information to his or her students and they were required to absorb it. It was in this atmosphere of thinking that Johann Heinrich Pestalozzi proposed that learning should begin with observation and discovery. In the early 1800's, he began efforts to see that mathematics would become more intuitive for students so they would have more understanding of arithmetic. This inspired Warren Colburn to push for major reform in mathematics education by questioning the method of memorization to teach arithmetic, which had been the primary method of instruction since the seventeenth century (Sztajn, 1995).

Colburn published a book in 1825 which began one of the first academic debates over the methods of teaching mathematics. He believed that arithmetic should not be taught by making students memorize abstract rules and then calculate numbers they do not understand. Colburn advocated that the natural learning process began with observations of things that we do understand. He wanted the students to make these observations and then discover the rules and generalizations on their own. Colburn also believed that students should not only be evaluated on correct answers, but should be able to explain how the students arrived at those answers. Although his focus was on student understanding, he did not throw out the importance of mental discipline that marked his era. He simply felt math should be taught through a different approach. Colburn's ideas had many supporters, but also faced much criticism. Eventually, the reform failed to make a great impact and the main method of instruction continued to be memorization and drill. Colburn's ideas have created an ongoing debate and the same issue of memorization vs. understanding is still one of the main topics of the current reform (Sztajn, 1995).

There have actually been three different reform movements during the twentieth century which have changed, or have attempted to change, how mathematics is taught. The first reform took place at around the turn of the century and is known as the Chicago movement. This reform was begun by professors in Chicago and throughout the midwest. Their desire was to see the math curriculum at the secondary level by combining algebra, geometry, and physics into a four year course. These ideas were met with swift opposition from math scholars on the east coast and the proposed reform only took place at the middle school level (Kilpatrick, 1997).

The second reform of this century was much more successful and is still remembered by many people today. In the 1950's, university professors were becoming increasingly unhappy with the quality of math education that students were receiving in the high schools and they launched a reform that developed into what is known today as the "new math" (Kilpatrick, 1997, p.956). This reform was unique because professors at the

university level joined up with teachers at the secondary level to make the necessary changes in curriculum. The new math movement focused only upon content and did not include many changes in teaching methods. The movement was led by university mathematicians who were predominantly specialists in the area of pure mathematics, which significantly influenced the changes that resulted from the reform. The driving motivation of these was to develop a curriculum that would prepare students to become mathematicians at universities (Kilpatrick, 1997). Therefore, the new math curriculum was extremely formal and heavily laden with pure mathematics. It emphasized proofs, postulates, and formulas, but lacked real life applications. Due to its emphasis on formalism, the new math was also the recipient of much criticism (Wu, 1997).

The main opponent to the new math was a man named Morris Kline who lashed out at the ideas advocated by the new math curriculum. He rejected the abstract formalism that filled the new textbooks and called for real-life application problems to be the focus. He felt that math should be connected to other disciplines by tying history and science to the lessons as well as other ideas to make math relevant to the students. Kline feared, and rightly so, that the formal math filled with rigorous proofs and abstract mathematical ideas would disinterest those students who needed an understanding of math for their daily lives, but would not likely become the future mathematicians. Although Kline's voice of opposition was not able to turn back the new math, he was correct in many of his predictions and his ideas are still looked to in the current reform (Kilpatrick, 1997). The issues that Kline brought to the forefront are the same issues that we are rehashing today.

Setting the Stage for the Current Reform

In 1983, a document called A Nation at Risk was published that has had a far reaching impact on education in this country . This document claimed that our nation was falling behind the rest of the world in education and would no longer be a leader in the world market unless we changed how we were training our young people in schools (Kilpatrick, 1997). This caused a major shift of focus upon the educational system and we

began to re-evaluate how every subject was being taught. It was at this time that The National Council of Teachers of Mathematics (NCTM) began to lead the way in attempting to reform math curriculum and instruction (Reys, 1997). The initial NCTM recommendations "emphasized problem solving and applications; reexamination of basic skills; incorporation of calculators, computers and other technology into the mathematics curriculum, and more mathematics for all students" (Manouchehri, 1997, 197). These initial efforts set the course for an event that would have the potential to radically change mathematics.

This event came in the form of a document called Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) which had as much influence in the field of mathematics as A Nation at Risk had on all of education. This document became the standard by which the reform was to be measured over the next ten years. The NCTM standards call for a move away from the new math that was established in the 1960's and for more emphasis on problem solving, cooperative activities, higher level thinking, connection of ideas, active learning, and increased understanding within mathematics (Futch, 1996). The NCTM standards did not receive immediate opposition because the ideas it presented are very general and were not initially viewed as threatening to anyone (Kilpatrick, 1997; Reys, 1997). The evaluation provided "the direction, but not the mechanism, for reform in school mathematics" (Manouchehri, 1997, p. 198). It was only after professors and organizations began to develop curriculum and teaching methods to implement the NCTM standards, that the current reform became subject to receive criticism and debate. It soon became clear that these standards were not going to require small change, but had the potential to fundamentally transform the way that school mathematics was going to be taught.

Issues of the Reform

Many of the issues that we have seen from the past are issues that are taking center stage again today. Most of the controversy lies in what should be taught and how it should

be taught. The arguments about what should be in the curriculum can usually be narrowed down to the debate between pure and applied mathematics. We have seen people disagree on whether math should be taught from a extremely formal or completely utilitarian approach and this issues has still not been settled. The main controversy in how math should be taught is also an old idea with a new name. The reformers want to use a method of instruction called constructivism, which involves the discovery approach to learning. This method is related closely to the ideas that Colburn was advocating 150 years ago. These two areas will encompass most of the issues we will consider.

As was stated earlier, not many people were opposed to the general ideas presented in the NCTM standards at first. Most people would agree that more students should be involved in math in an active way. However, there is a great amount of controversy about how that task should be accomplished and the division is mostly caused by whether a person thinks the emphasis in math should be on pure, formal math or on applied, real-world math. The reform is calling for more of a utilitarian approach to mathematics where the focus is upon teaching students math that they can use and understand. An increasing number of students are turned off to math and one of the goals of the reform is to make math more relevant to a greater number of students. The NCTM standards lean heavily toward approaching math through applications with the justification that students will gain more understanding of math and become better problem solvers. In the past, math has been composed mainly of rules, numbers, and symbols and it seems that underlying principals, concepts, and problem solving got lost (Ross, 1996). Today, reformers want students increase the students understanding of math by teaching them the big picture.

This approach tends to make many university professors nervous, because they do not want the elementary and high school math curriculums to become absent of formal math. As was discussed before, these professors have an interest in the future scientists, engineers, and mathematicians of the world and view this reform as a threat to their development. Hung-Hsi Wu of Cal-Berkeley is one of the most vocal critics of current

reform efforts (Kilpatrick, 1997). Dr. Wu (1997) contends that the problem of removing formal, rigorous math from the curriculum is that it will hinder those who decide to enter the field of math later in life. He feels that this emphasis on applications and will not only impair the development of mathematicians, but will ultimately slow the progress of pure mathematics. Peter Glidden (1996), a professor a West Chester University said, "it is reasonable to expect college-intending students to be familiar with the structure of mathematics" (p. 451).

While it is understandable that university professors feel this way, it is not a strong enough argument to hold back the reform efforts which intend to involve more students in mathematics in ways that they can understand. Dr. Wu (1997) himself stated that only one percent of all college calculus students become mathematicians. This means that we are trying to keep a system that prepares one person and ignores the needs of 99 others. "A society demanding mathematical literacy from all its citizens cannot afford to continue mathematics education for the few" (Acquarelli & Mumme, 1996, p.484). Facing the reality that not every student in a high school math class is going become a mathematician, we need to focus on the needs of the majority while still preparing students for high level math.

A major issue to settle is whether or not this shift in emphasis will really inhibit the development of future mathematicians. The main fear of mathematicians like Dr. Wu (1997) is that the curriculum will leave out key formulas and will present concepts without paying attention to formal proofs in the process. The informal, intuitive proofs that he is seeing in the reformed materials being published are not valid in his opinion and will not prepare the students for higher level math. The problem with Dr. Wu's thinking is that he misinterprets the idea of students doing less proofs as the complete elimination of proofs from the curriculum (Kilpatrick, 1997). Few would say that proofs should be eliminated completely from math education, but many are willing to limit the proofs to gain more student interest.

The solution to this issue must be found in balance. We should not teach a form of mathematics that is designed only to lead to the narrow field of pure mathematics when so many students are going to need a general understanding of math to succeed in a increasingly technological society. We simply cannot ignore the well being of the majority. At the same time, we must not stop the progress of pure mathematics by failing to prepare our students to be ready for that field. It must be possible that we can move toward an emphasis in applied math where students understand the concepts behind math and still give attention to the formal proofs and details of mathematics. The goal is to help students understand math and not just have them grind out thoughtless answers (Ross, 53). The answer must come in a balanced package where the average math student can be motivated to see how math relates to his or her life while the student who is bound to become a mathematician will still receive the preparation that he or she needs.

There are issues concerning how math should be taught that cause just as much debate as what should be taught. These issues are centered around the teacher and his or her methods of instruction. A lot of research has recently been released which is challenging many of our older ideas of how teaching and learning should take place. In the past, educators have thought that the best way to teach is to have a teacher lecture information and have the students absorb it. Today many people believe that the most meaningful learning takes place in an active environment where the teacher becomes a facilitator for students to discover information and ideas in a more autonomous way (Manouchehri, 1997). The of this pedagogical style that promotes a discovery-oriented approach to learning in which the students knowledge is built on their experience is called constructivism (Kilpatrick, 1997; Manouchehri, 1997). This idea is similar to what Colburn was presenting over 150 years ago and is sparking a lot of controversy today. This issue is not really confined to the field of mathematics, but is an issue that all of education is discussing. Due to the size of the debate on the topic of constructivism, we will not fully cover the issue, but only briefly present how it is affecting math reform.

Dr. Wu (1997) has a strong dislike for the constructivist strategy for teaching. He agrees that the reform has done some good by replacing some of the rote methods of the past with more active and motivational methods of learning, but uses constructivism and the discovery method of leaning far too much. This seems to be more of a personal opinion from Dr. Wu rather than a real argument against reform efforts. It is true that most of the new textbook and materials being produced support constructivism, but Dr. Wu does not provide any strong evidence showing that students will not learn this way. It seems that the idea of a teacher as a facilitator, rather than the one dispensing all of the information, is a challenging idea to him which he would possibly prefer not doing. I believe that it makes sense to give the students responsibility in their own learning and allow them to make some of their own discoveries. This can be brought into balance by Dr. Wu by saying that the teacher is still ultimately responsible to see that the students understand the information and helping them if they do not.

What Happens Next?

Now that we understand the issues and can see that the reforms, taken with some caution and balance, are bringing positive changes, what are the next steps to implementation? Once the decisions have been made on what changes are needed in the curriculum and methods of teaching, the two keys to making the changes successfully take place are proper teacher training and open communication. Without these two needs being met, all the hard work that has taken place may have been done in vain.

"If the mathematics curriculum changes as proposed, the need for competent teachers will become more acute" (Manouchehri, 1997, p. 197). The teachers themselves are probably the biggest factor in a successful implementation of the changes at hand (Reys, 1997). It would seem reasonable that teachers gain their beliefs about teaching from their own experience as students. Since most of the current teachers have been educated in a traditional setting themselves, it makes it difficult for them to make the expected adjustments and changes in their teaching (Acquarelli & Mumme, 1996). Teachers are

going to have to see and experience good teaching by the reformed methods before they will be able to use the reformed textbooks and instruction methods in their own classrooms. These changes in the school mathematics must be accompanied by adequate staff develop for those currently teaching and reform in teacher training for teachers of the future (Manouchehri, 1997). Even Dr. Wu (1997) agrees that all of the positive aspects of this reform will be in vain if teachers are not better trained.

The second key to the success of the reforms was open communication. Communication needs to take place within the mathematics community to come to a collective and balanced approach in deciding what changes will be made to better school math (Reys, 1997). Communication must also take place in the process of implementing the change. Obviously communication is a key to educating the teachers about the goals and philosophical ideas that drive the changes; however, educating the parents of the community of the reasoning behind the changes is just as vital. Even if the mathematics community develops a consensus regarding the changes, the parents must also understand and be involved in agreeing to the changes because it is their children that they will affect (Peressini, 1997; Ross, 1996). There are parents in the Vancouver school district that have seen the textbooks that their children are using and do not understand why they are being used. They become frustrated because no one is willing to answer their questions. This same situation took place in California and the parents fought back, completely reversing the efforts that had been made to reform math there. Though there may have been other significant problems other than the lack of communication, it is clear that the parents' lack of being informed notably hindered those reform efforts (Vogel, 1997). It is a fact of life that people tend to resist and fear changes. It is clear then that communication must be open to make every effort to alleviate the fears and move on toward successful math instruction.

It is clear that the current reform in mathematics is not a simple matter. It requires a look into the past and a clear assessment of the present issues before we can decide what is

best for the future. Though the voices opposing the reforms are beneficial in providing caution, consideration, and balance, the changes have been long awaited and must take place. They are carried by good philosophy and motivations to try to reach more students and make mathematics relevant to their lives. Wisdom must also be taken in making these changes a reality by properly training teachers and informing the public. Ultimately, the goal must be "to teach better mathematics and to teach mathematics better" (Kilpatrick, 1997, p. 962).

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