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ABSTRACT

The life cycle of "new math" is fertile ground for the study of the diffusion of an innovation. New math arrived in 1958 to save the day for America after the Soviet Union launched Sputnik, the first successful space flight in 1957. In a period cf 16 years an entire diffusion cycle was completed throughout the entire educational system of the United States. In some cases, new math was a success; in others it was a failure. The success of the classic diffusion of innovations model in this case history of new math is its delineation of the elements of the diffusion process. The four main elements in the diffusion of innovations are: (1) the characteristics of the innovation; (2) communication channels, time, and the social system. As evidenced by the available public opinion polls and the literature of the day, none of the attributes of new math, the existing communication channels, the rate of diffusion, nor the nature of the social system were favorable regarding the diffusion and success of new math. The inability of the diffusion model to predict consequences (both positive and negative) is one of its primary flaws. By making use of the lessons of new math, perhaps educators can ease the diffusion of new innovations that must take place if students are to be prepared for life in an ever more complex world. (Two figures of data are included and 33 references are attached.) (RS)

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The Diffusion of New Math

"We Do Not Teach Them How to Think" declares the author of a New York Times Magazine article (Raeff). The Vice President of the United States offers the public "A Challenge to American Education" (Nixon). A public opinion poll indicates support for "reappraising U.S. education" (O'Neil).

These could be headlines in any 1992 publication, but in fact these three examples are dated 1958 and what makes them different from their 1992 counterparts is that they did indeed herald change for U.S. schools.

In October 1957 the Soviet Union launched Sputnik, the first successful spaceflight. America's leaders and citizens were caught in a panic as fear of losing our technological advantage swept the nation. The inadequacies of American education became glaringly apparent and calls for educational reform reverberated throughout the land. No subjects were more suspect than science and mathematics. Surely America would have made it to space first if our students were being taught science and math more diligently and purposefully, or so the reasoning went (Miller 76, Strehler 68, 84).

Into this highly emotionally charged atmosphere arrived "new math" to save the day and deliver the final frontier of space into the waiting arms of the American public. But something went wrong. By the middle of the 1960's new math was in trouble and there was discontent in the ranks as the efficacy of the new math was being called into question (The Trials of New Math). In 1974, just 16 years after Sputnik, the death knell for new math sounded with the publication of a book entitled "Why Johnny Can't Add: the Failure of New Math" by Morris Kline (Kendig, 14).

The public opinion polls of the day did indicate a desire for improvement and change in the American schools. Eighty-nine percent of the sample surveyed in a 1958 Gallup poll indicated that they believed mathematics should be a required subject in school (Gallup 1525). A "representative sample of high school principals in all 48 states were asked: Have you made, or are you planning to make, any changes in the requirements or the curriculum of your high school in line with the suggestions which have been made since Sputnik?" Twenty-three percent said they had already made changes; twenty-nine percent indicated they were planning to make changes; three percent had made some and were planning others. Forty-five percent planned no change. (Gallup 1547).

The results of a poll published in Life magazine indicated that following Sputnik the public's opinion of the most important problems facing the nation changed from "1) inflation, 2) keeping out of war, and 3) segregation" to "1) catching the Russians in the defence race, and 2) training more and better scientists." (O'Neil, 91-92). When asked "Do you think Russia or the U.S. has the best high school training in mathematics and science?" The following results were obtained: "Russia: 39%; United States: 28%; Both the same: 4%; Don't know: 29%." (O'Neil, 96).

American leaders were calling for change. The American public seemed to support the call. Why did new math fail?

Diffusion of Innovations

In his book Diffusion of Innovations Everett Rogers proposes a model for the study of the diffusion of an innovation throughout a social system. Diffusion is defined as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 5). The model was derived from studies conducted in a multitude of disciplines but even Rogers suggests that the convergence of many research traditions into a single process model may provide a too narrow framework in which to conduct research (Rogers 39).

According to Rogers there are four main elements in the diffusion of innovations: the characteristics of the innovation, communication channels, time, and the social system. Within each of these broad categories any number of factors will determine the success or failure of the proposed innovation. (Rogers 10-34). A simplistic summary of the diffusion of innovations would suggest that if the innovation has all the right attributes, and is communicated through appropriate channels in a reasonable amount of time, then the individuals within the social system will adopt the innovation--success!

In the "Consequences of Diffusion of Innovation" Kevin Goss summarizes some of the major criticisms levied at the classical diffusion model. According to Goss the diffusion of innovations has an "individualistic or psychological bias;" it fails to examine the social structure into which the diffusion is introduced and examines only the adoption behavior of the individuals targeted for change. The "social structural factors are more complex than simple aggregation of individual characteristics, yet most diffusion research has focused on the latter. They also show the phenomena of undesirable consequences, and yet diffusionists have done little research in this area." (Goss 756-758).

Educational innovations are routinely adopted while little is known about their effects on students. (Wolf 88). However, the study of an innovation in an educational setting is particularly difficult. The conditions for change, and the characteristics of the innovator, the innovation and the target audience must be examined as a complex web of interdependencies that will effect the success of a proposed innovation (Wolf 10). The common view is that if the proper innovation is identified, funded and introduced properly, the rest will take care of itself (Gross 208). A means of predicting the success of an innovation and its diffusability is needed in order make decisions about whether to proceed with the diffusion effort (Caffarella 16). "Information pertaining to attributes of innovations, drawn from disciplines such as sociology and anthropology, may not generalize meaningfully to disciplines such as education" (Allan 333).

Richard O. Carlson studied the diffusion of new math in his 1965 study Adoption of Educational Innovations. The study was limited to the adoption practices of superintendents in Pennsylvania and West Virginia. He examined the perceived characteristics of the innovation, the rate of adoption as defined by the superintendent's decision to adopt, and the consequences of the adoption of one particular method. Now, more than twenty years after Carlson's study and the de facto failure of new math, it is necessary to examine why new math failed as a national movement.

Based on public opinion polls and popular articles of the day it is possible to apply Rogers diffusion model in order to assess the flow of the new math craze through the corridors of American schools. Why did new math fail--or did it?

Attributes of Innovation

What is new math?

Several separate mathematics revision movements coalesced into what eventually came to be called new math. The most notable proponents were Max Beberman of the University of Illinois and Edward Begle of Yale and later Stanford University (Kline 15-23, Miller 76). In contrast to the traditional teaching of mathematics which emphasized rote learning and memorization, new math focused on discovery of math properties and the development of strategies for problem-solving. (Mayor 376). It was hoped that if students were led to discover principals of math this new way they would understand and enjoy it (Kline 24).

Allen Strehler delineates five characteristics of the new mathematics:

1. It eliminates those topics that are relatively unimportant.
2. It integrates those topics that are important.
3. It introduces recent and important developments in mathematics.
4. It emphasizes the structure of mathematics, rather than isolated topics.
5. It introduces subject matter to students earlier than was previously thought possible. (Strehler 69).

In summary Strehler says "the new mathematics is essentially a renewed mathematics--renewed in the attention it has attracted from many interested participants and observers; in the searching re-examination that has been forced upon its pedagogical intricacies; and in its increased importance in an age and society deeply involved in technology" (Strehler 84).

How does new math measure up to Rogers' diffusion model? The model describes five attributes necessary for the diffusion of an innovation. These attributes are "(1) relative advantage,

(2) compatibility, (3) complexity, (4) trialability, and (5) observability" (Rogers 211). However, a study conducted by Allan and Wolf concluded that "innovation attributes selected for study provided marginal insight into adoption of educational innovations" (Allan 336). An examination of new math in relation to Rogers' attributes yields interesting results.

"Relative advantage is the degree to which an innovation is perceived as being better than the idea it supersedes. The degree of relative advantage is often expressed in economic profitability, in status giving, or in other ways" (Rogers 213). What was the relative advantage of new math?

In order to examine this and other questions postulated later in this paper it is important to examine the public opinion polls and popular literature of the day in order to try to infer what goals the public had in mind when calling for change. Unfortunately, the polls in 1958 did not ask for opinions about specific proposals in education reform. In general, the public believed that students should work harder and take more mathematics and science; in reaction to progressive movements the public felt that the schools should focus on developing intellect not social skills; and, more money should be forthcoming to the schools (O'Neil 96-98).

The seeds of support for the new math movement are to be found in an article in the New York Times Magazine entitled "We Do Not Teach Them How to Think" by Marc Raeff, a professor of history at Clark University. In this article Mr. Raeff declares that there are two things fundamentally wrong with American education: "it does not train for mental work and it teaches little." In his view the solutions were obvious: "accustom him [the student] to systematic, constant, hard work...a stiff program and great demands on their time and effort [to] stimulate and encourage them...build up a store of knowledge for later use..." (Raeff 7). In short, Professor Raeff proposed that more rigorous academic demands would develop the faculties that would enable students to <u>think</u>.

Therein lies the key to the relative advantage of new math. Suppose a curriculum was developed that purported to teach students to think, prepared students for a new age of technology, and, most importantly, was fun. Of course the public would embrace new math; but that's not what the public was calling for. According to Professor Raeff and the public who unanimously agreed with his position in the Letters to the Editor (Do We Teach Them to Think?) fun wasn't part of the equation, facts and discipline were. New math abandoned rote learning in favor of getting children excited and interested in learning (Mayor 376). New math had relative advantage, but it wasn't the advantage the public was looking for.

"<u>Compatibility</u> is the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters" (Rogers 223). New math required a complete change in mathematics curriculum, teacher training, textbooks and materials. Unfortunately, the implementation of the revolution was haphazard (Miller 76-83). Well into new math's takeover in an article entitled "Progress Report on the Mathematics Revolution" one mathematics teacher/author urged "a take-over that is gradual, sound and thorough. Crash programs run into difficulties in any line. A middle of the road approach, fusing the old math with the new, gives the best results" (Sharp 63). However, as the article's title stated this was a revolution; revolution's are not compatible with the old regime.

"Complexity is the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers 230). However, complexity is far more complex that this simple definition implies. "The complexity of an innovation dictates a number of subsequent requirements such as specialized personnel, training, resources or facilities; the level of change called for; the formality of communication channels needed; and the investment of time and effort necessary to enable prospective clients to adopt that innovation" (Wolf 10)

Was new math complex? You bet it was. Across the nation teachers, parents and students struggled to learn the new concepts. "The teachers...are frightened. They don't understand the new math or why they are supposed to teach it" (Teaching: The Trials of New Math). "Parents are left floundering with alien concepts" (Maxey 84). New math required that teachers return to school and abandon everything they previously had learned about mathematics and how to teach it and start again from scratch (The New Mathematics). Compounding the problem there was a shortage of courses at colleges and universities for training teachers in the new math (The Trials of New Math). In an article entitled "Introducing Parents to Modern Mathematics" an Arlington, Virginia mathematics teacher describes the very successful parent education program that was implemented in order to teach parents what their children were learning (Franklin). Unfortunately, not every school had the resources to implement such a program and this program seems the exception rather than the rule.

"<u>Trialability</u> is the degree to which an innovation may be experimented with on a limited basis" (Rogers 231). This definition poses a problem in the educational setting; a problem that certainly describes the lack of trialability in the new math movement. "Rogers model is concerned with the adoption of simple technological innovations by individuals, and it assumes they can try out innovations on a small scale without the help or support of other persons. It also assumes that persons can undertake trials in an either/or fashion and that short trials are sufficient to render an effective evaluation. Many educational innovations, however, cannot be tried on a small scale and cannot be implemented by teachers unless they have the support and cooperation of their colleagues. Furthermore, many educational innovations are so complex that they cannot be tried in an either/or fashion, and some require several years of full implementation before an adequate evaluation of their effectiveness can be made" (Gross 22).

Rogers also states "the trialability of an innovation as perceived by members of a social system is positively related to its rate of adoption" (Rogers 231). The new math craze took off at a furious pace following Sputnik (Miller 76); consequently there was no time to try the innovation prior to adoption.

"Observability is the degree to which the results of an innovation are visible to others" (Rogers 233). It would be impossible to observe a new curriculum in order to make determinations about its effectiveness without considering the consequences. Initially new math looked like the answer to the nation's Sputnik-induced paranoia (Math is Fun 44-45), but it wasn't long before an article in Look magazine declared "Today's curriculum reform was forced on us" (Maxey 88). It seems the public had observed new math in action and they didn't like what they saw.

A 1966 Gallup public opinion poll published in Time corroborates these findings. When "asked to rate 48 possible goals of education, parents particularly prize the development of such personal qualities as honesty, respect for authority, and respect for other races and religions...but mathematics beyond simple arithmetic rates near the bottom of the list" (How Parents Feel).

Communication Channels

"A communication channel is the means by which messages get from one individual to another. The nature of the information-exchange relationship between the pair of individuals determines the conditions under which a source will or will not transmit the innovation to the receiver, and the effect of the transfer" (Rogers 17). Carlson studied the communication channels that led to the adoption of new math in a particular community. In this study adoption of the new math innovation follows Rogers' model of communication channels, but it is important to note that adoption was defined as the superintendent's decision to adopt (Carlson 10). According to Gross "adopting the change at the administrative level does not mean successful implementation in the school" (Gross 21).

Significantly, in public opinion polls examined for this paper communication about new methods in education was considered inadequate. "The public would like more information about modern education--the new methods being tried and new ideas about the kind of education that is needed. In short, people...need information that is presently not provided by the various media of communication" (Elam, Gallup Polls 11).

The 1969 Gallup polls indicate the public's best source of information about local schools is the local newspaper (38%) and that during the last month they had read an article concerning education (60%). Forty-two percent of the sample surveyed in 1977 thought the media gave a "fair and accurate picture of the public schools in this community." Significantly, 36% felt that the representation was not fair and accurate. (Elam, Topical Summary 7-8).

The 1977 survey also asked respondents to list ways in which coverage of schools could be improved. "The most frequent response focused on the need for more positive news-interesting things the schools were doing to achieve their educational goals." Specific suggestions included: "It would be interesting to find out about all the different courses that are offered...I should like to know more about the changes that are being introduced and why. There should be more background information about education and about new programs...I wonder if our local schools go in for these new ideas" (Elam, Topical Summary 8).

Unfortunately for a case study of new math these questions were not asked at the height of the new math craze. However, it is possible to infer that the attitudes and opinions expressed by the public in these polls were formed over the significant 1958-1974 era and are thus applicable to this discussion.

Time and the Social System

"Rate of adoption is the relative speed with which an innovation is adopted by members of a social system. It is generally measured as the number of individuals who adopt a new idea in a specific period" (Rogers 232).

"It is still true that a translation of Euclid's "Elements" written over 2,000 years ago, used with a mimeographed set of exercises, would be considered acceptable classroom material for many 10th-grade geometry courses" (Mayor 376). Innovation in education occurs slowly. Early studies indicated that a normal rate of diffusion of an innovation in education would ordinarily take a full century. The process was described thus:

> Between insight into a need...and the introduction of a way of meeting that need that is destined for general acceptance...there is typically a lapse of a half-century. Another half-century is required for the diffusion of the adaption. During that half-century of diffusion, the practice is not recognized until it has appeared in 3% of the systems of the country. By that time, fifteen years of diffusion--or independent innovation--have elapsed. Thereafter, there is a rapid twenty years of diffusion, accompanied by much fanfare, and then a long period of slow diffusion through the last small percentage of school systems (See Figure 2) (Mort 318).

Mort's analysis of the adoption of innovation in education follows Rogers' s-curve of adoption. "The s-shaped adoption distribution rises slowly at first when there are few adopters in each time period. It then accelerates to a maximum until half of the individuals in the system have adopted. It then increases at a gradually slower rate as the few remaining individuals adopt" (see Figure 1) (Rogers 244).

Figure 1: The S-Curve of Adoption (Rogers 243)

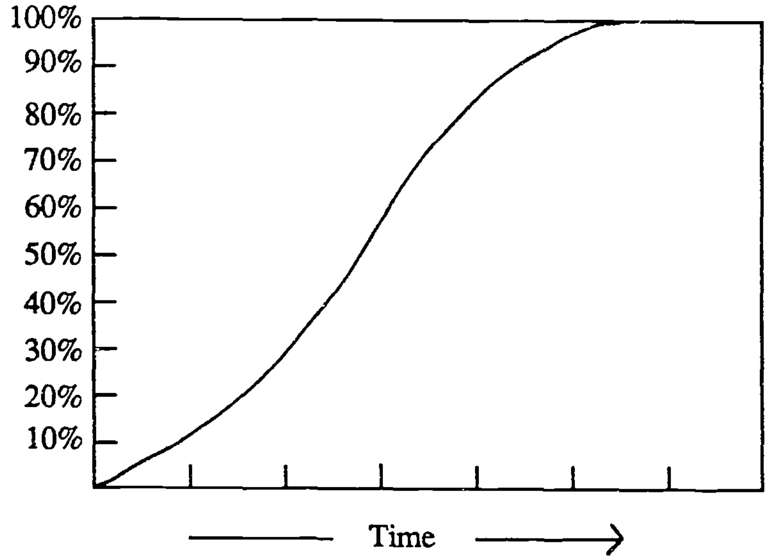
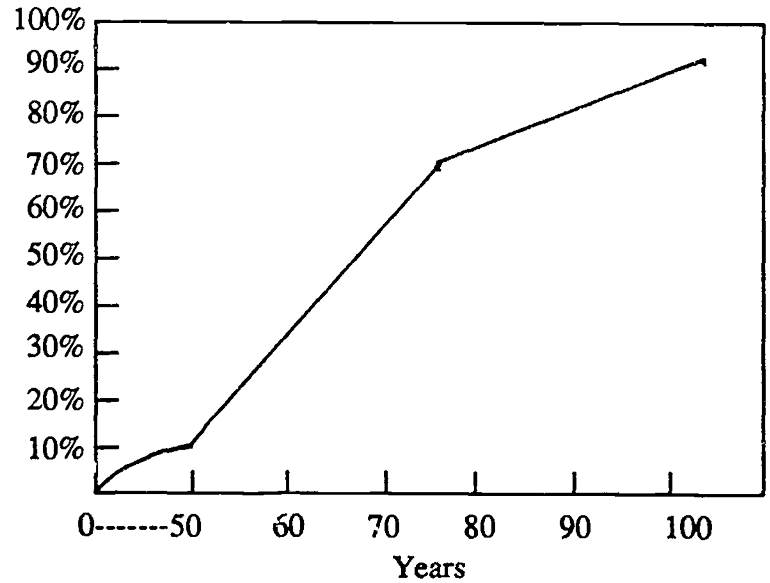


Figure 2: The Rate of Adoption of Educational Innovations (Mort 318)



New math did not follow the typical diffusion pattern for new innovations in education or in theory. Discontent with America's schools, particularly with science and math curriculum, was evident during World War II when military leaders realized that the average citizen/soldier did not possess the basic skills necessary to succeed in a technological society. Other factors also were forcing the reassessment of American schools during the post-WWII/pre-Sputnik era: the mass infusion of mature students into colleges and universities due to the access afforded returning servicemen and women thanks to the G.I. Bill; the swell in the population of the elementary schools due to the baby boom; racial integration; and, a teacher shortage were also factors (Jennings 77-79).

Sputnik, however, was the catalyst for accelerating the diffusion of the innovations that were being developed. Following Sputnik "a sense of urgency surrounded the ever-present task of revising curricula and courses; and in the past five years [since Sputnik] mathematics teachers have found themselves beset by new proposals to do this and do that...The controversy and confusion that now surround the <u>new</u> mathematics is due in part to the haste with which this reappraisal was undertaken" (Strehler 68). "Any movement coming in the early period of turbulence is destined to be abortive" (Mort 323). New math arrived on the scene in just such a period of turbulence.

Public support for new math (and other innovations in the schools at the time) was indicated in the amount of funding made available during its lifetime. Immediately after Sputnik the federal coffers opened in support of educational innovation (National Education Association 7-11). "By the mid-1960s more than half of the nation's high schools had adopted some form of the new-math curriculum. The figure jumped to an estimated 85 percent of all schools, kindergarten through grade twelve, a decade later...[by the late 1960s] Popular sentiment was beginning to shift, and with it congressional enthusiasm for the financing of educational reform." Federal funding for new math ended in 1971 (Miller 76-83).

Did new math fail?

Consequences of New Math

As discussed earlier one of the primary criticisms of Rogers' early diffusion model was that it ignored the consequences of adopting the innovation (for example see Goss). The later model (1983) addresses the consequences of the diffusion of an innovation. Rogers states "consequences are the changes that occur to an individual or to a social system as a result of the adoption or rejection of an innovation. An innovation has little effect until it is distributed to members of a system and put to use by them...researchers have given little attention to consequences...they assume that adoption of a given innovation will produce only beneficial results for its adopters" (Rogers 371). What were the consequences of new math?

Consequences for individual students varied. Some students flourished under the new math; others failed miserably. A <u>New York Times Magazine</u> article entitled "Does New Math Add Up?" drew a mixed response from readers. One young lady replied that she was an honor student who had learned the theory behind division but couldn't do it. Her mother, a high school graduate, didn't understand the theory, "she just did it. Maybe that's better" (Schnitzler). However, another respondent had just the opposite experience: after struggling years with the old math a teacher of new math sparked her interest. "Her rigorous demonstration started me on my career and I now have a doctorate in mathematics. Hurrah for the new math!" (Longyear).

The consequences of the new math revolution on the American educational system are far-reaching. In "We Need Another Revolution in Secondary School Mathematics" Zalman Usiskin summarizes the lasting effects of new math:

> Discovery teaching is not in wide use today. Yet the larger changes in course structure remain with us...Thus the current secondary school curricula in the vast majority of schools in the United States and Canada reflect the new math revolution...thus in some ways the new math was quite successful. Yet the public view is that this revolution was a failure. The public perception cannot be dismissed lightly...(Usiskin 2-3).

Conclusion

The success of the classic diffusion of innovations model in this case history of new math has been its delineation of the elements that must be considered in the diffusion process. As evidenced by the available public opinion polls and the literature of the day, none of the attributes of new math, the existing communication channels, the rate of diffusion nor the nature of the social system were favorable regarding the diffusion and success of this innovation. Had educators been able to predict the consequences of diffusing new math the nation may have been able to avoid a period of turmoil, trial and error that has left a lasting mark on all who were part.

The inability of the diffusion model to predict consequences both positive and negative is one of its primary flaws (Goss 766). Is it possible to develop a tool capable of predicting the future?

Instead of seeking a prediction capability, the diffusion model must incorporate a guidance system into its design. This guidance system would allow innovators and change agents to assess the public's perceptions of the innovation, the climate into which the proposed innovation is being introduced, and the consequences of the innovation from introduction to adoption or rejection. The tools for accomplishing this task are specific and probing public opinion polls.

The annual Phi Delta Kappa/Gallup Public Opinion Polls on Attitudes Toward Education did not begin in earnest until 1969

(Elam, Gallup Polls 1). Imagine if individuals in 1958 had been probed to find out what was meant when they said they favored a change in education particularly in math and science. Did they favor a complete overhaul in mathematics education that would emphasize the discovery principals of mathematics but abandon simple problem solving? The results would have been interesting--and may have eased the introduction of new math into the traditional curriculum. Hindsight is 20/20 and of course these polls were not conducted in 1958, but we can learn from the experience.

Public opinion polls conducted throughout the diffusion journey would allow the proponents to assess the public's perception of the attributes of an innovation, the rate at which it is being adopted or rejected, the effectiveness of the communication channels and the consequences--negative and positive--for the individuals and for the system effected. As guides the polls can indicate when and where modifications, if any, are needed, whether the innovation is a complete success, or whether it should be abandoned.

The life cycle of new math is fertile ground for the study of the diffusion of an innovation. It is a unique episode in the annals of U.S. history. In a period of 16 years an entire diffusion cycle was completed throughout the entire educational system of the United States. In some cases new math was a success; in others a failure. This case study has attempted to examine the national diffusion trend as reflected by available public opinion polls and literature of the day. A myriad of questions remain on this topic and should be explored so that we may make use of the lessons of new math. Perhaps we can ease the diffusion of new innovations into our school's curriculum, innovations that must take place if we are to prepare students for life in an ever more complex world.

Sputnik was only the beginning.

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