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Analog or digital, a comparison of two clock faces used for teaching students to tell time

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Abstract

Several years in the classroom as a fifth grade math instructor has left this instructor with many questions and concerns. One of the most intriguing is: does tlra type of clock face used during instruction have any effect on a student's ability to understand the concept of time·and the ability to tell time? With modern technology, digital time devices are becoming more and more common in our society. Many students can successfully read these digital clocks, but still have a difficult time actually understanding the meaning of what they have read. Two completely and distinctly different mental tasks were involved. One task concerns the understanding of the concept of time, and the other the reading of a time measuring device. The concept of time includes the passage of time, chronological sequencing of events, and the duration of time periods. The skill of telling time deals with the ability to read a clock, recording that time, and predicting times after determined intervals (Horak and Horak, 1983).

Analog or Digital, A Comparison of Two Clock Faces Used for Teaching Students to Tell Time

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Several years in the classroom as a fifth grade math instructor has left this instructor with many questions and concerns. One of the most intriguing is: does the type of clock face used during instruction have any effect on a student's ability to understand the concept of time and the ability to tell time? With modern technology, digital time devices are becoming more and more common in our society. Many students can successfully read these digital clocks, but still have a difficult time actually understanding the meaning of what they have read. Two completely and distinctly different mental tasks were involved. One task concerns the understanding of the concept of time, and the other the reading of a time measuring device. The concept of time includes the passage of time, chronological sequencing of events, and the duration of time periods. The skill of telling time deals with the ability to read a clock, recording that time, and predicting times after determined intervals (Horak and Horak, 1983).

To help understand the difference between the concept of time and the ability to tell time, the methods used by children to learn these concepts need to be discussed. Children's perception of time begins

very early in their lives. The perception of time (Piaget, 1969; Lovell and Stater, 1960) starts from a mere surface contact with immediate realities, and gradually develops into a grasp of objective time. This latter grasp of objective time is built up from a quantitative array of relationships between various events in the child's external world. Piaget (1969) goes on to note, that it is only when the child reaches the stage of concrete operational thought that reasoning about time can begin to take place. This entire spontaneous process is deeply rooted in the development of the child, and will be ignited by specific situations, teachers, and learning methods (Perry and Obenauf, 1987).

The type of instructional material used in teaching this concept of time becomes very important; it is also important when learning to tell time. Children can be taught at a very early age to read the ten numerals on a digital clock; they can do this before they have any understanding of what they mean. Until they reach the developmental stage that is necessary to understand the passage of time, their reading of the numerals on the clock face does not constitute an understanding of time. This development

of time needs to follow a spontaneous process that is deeply rooted in the biological development of the child (Piaget, 1969; Perry and Obenauf, 1987).

Current literature provides some answers to these intriguing questions, as well as, the results of research studies and the experiences of educators who have used both types of clock faces in their own classrooms. It also demonstrates what type of clock face these educators prefer to use in their instructional materials. This is a relatively new concern; it has appeared in just the past few years because digital watches and clocks have now become available on a large scale. This paper summarizes the most current information on this topic.

Educators need to know what type of clock face, digital, analog, or combination, should be used to teach the concept of time, and the ability to tell time. This review of literature answers the following questions:

1. Does the type of clock face used in instruction influence the student's ability to understand the concept of time?

2. With what methods of instruction do students best learn the concept of time?

In addition an analysis of current mathematics instructional materials was conducted to answer the following question:

1. Do current math instructional materials display digital, analog, or a combination of clock faces in their lessons on telling time?

This review of literature, and analysis of current mathematics instructional materials provides new insight regarding the type of clock face to use while instructing young students to tell time.

Three different sources of information were used to locate current literature on the topic of clock faces and their influence on instructional practices for teaching students the concept required for telling time. An ERIC, (Educational Resources Information Center) search was conducted through the University of Northern Iowa library, during the summer of 1987. In September of 1987, an INFORMS, (Iowa Network For Obtaining Resource Materials For Schools) Online Bibliographic Search was conducted by the local Area Education Agency. This search was done with the help of the Iowa Department of Education. Lastly, selected current mathematics instructional materials were inspected to determine what type of clock face they

used. Only instructional materials from 1972 to 1987 were analyzed because digital clocks really did not appear on a large scale before 1972.

Review of Literature

Many students and even adults do not understand the difference between telling time and the actual concept of time. The concept of time is really an act of sensing a point in time or the passage of time. The understanding of time involves the passage of time, sequencing events in chronological order, and the duration of various time periods. The ability of students to read numerals on a digital clock, does not demonstrate their ability to understand the passage of time, sequence events in chronological order, or comprehend the duration of time periods. Many students are just reading the numerals; they have not developed the concept of time (Jeffers, 1979). Riley (1980) states before students can actually tell time, they must possess the ability to place a series of events in correct chronological order. This ability to place events in chronological order begins to appear between the ages of seven and eight. Only then can a teacher begin to deal successfully with the concept of time. At this stage teachers should not accept the reading of

numerals on a clock face as telling time, but as a demonstration of the student's ability to recognize numerals. This concept of time should be taught before students are taught how to read a clock face, especially a digital clock face.

Teaching a student to tell time is very similar to teaching a student any other method of measurement. There are usually three instructional stages involved. These three stages of instruction are: (1) the student must develop an understanding of the concept, (2) the student must use relevant non-standard measures, and (3) the student must use universally accepted standards of measure (Burton and Edge, 1985). Most educators feel this understanding of the concept of time does not develop naturally and the systematic instruction found in current standard mathematics curricula is necessary. These three stages are very basic in nature; they also imply common sense. Before students can use any measuring system or device they must have an understanding of what they are measuring and why they are measuring it. In addition the measuring system or device must have relevance to the students and their world. If not, it will become another senseless academic activity. Finally, any standard of

measurement should be universally accepted in the student's real world. This allows for immediate and meaningful application as well as immediate ownership.

The most universally accepted sequence of lessons used in teaching students to tell time, begins with telling time to the nearest hour, then to the nearest half hour, then to the nearest fifteen minute interval, then to the nearest ten minute interval, and finally to the nearest one minute interval (Britton, 1981). Students are taught to begin with the hour hand and proceed to the minute hand. The movement and direction of both hands should be taught as each hand is introduced. This approach was utilized by most researchers and standard mathematics curriculum texts.

Teaching children to tell time is very similar to teaching any other measurement skill. But, telling time from a clock is a much more difficult task than determining the weight of an object by using a simple scale. To tell time correctly and fully understand what it means, takes more instruction than any other type of measurement skill. This is one reason the type of clock face used in the instruction is so important.

Only recently have educational researchers started to question the influences of digital versus analog

clock faces on teaching students to tell time. In fact, very few studies to date, have been conducted in this area. To demonstrate the newness of this area of concern, research studies, from 1969, 1981, and a direct comparison of digital and analog clock faces, from 1985, are discussed. These studies from the past nineteen years demonstrate how the concern has evolved, from, "how the concept of telling time is developed," to "what is the best method or device (type of clock face) to utilize in teaching students to tell time."

The purpose of the first study (Stephens and Dutton, 1969), was to determine the capacity of kindergarten students to develop mathematical concepts needed to tell time. In other words, are kindergarten students ready for the systematic mathematical instruction needed to tell time?

A quasi experimental design was used, as the classes were not randomized; a pretest and post test was administered, with a treatment in between. A Time Concept Test was prepared by Stephens and Dutton, based upon the preliminary work of Doris V. Springer in 1951-52. This test became the pretest and post test. The treatment consisted of a six week program in developing time concepts, using an analog clock. Lessons were

prepared and provided for each teacher. Mean test scores were determined for both the pretest and post test. Significant growth was demonstrated by all classes; in fact, the mean test scores doubled from the pretest to the post test. Among the concepts and vocabulary terms that were found to be extremely effective were: (1) recognition and naming of the circle; (2) fractions, such as one half, one quarter, three quarters; (3) clockwise direction; (4) slower; (5) faster; (6) before; and (7) after. These concepts and vocabulary terms can only be applied to an analog clock.

The purpose of the second study (Nibbelink and Witzenberg, 1981) was to compare two different methods of teaching students how to read a clock. One method, which will be identified as Method A, used the traditional method, telling time on the hour, half hour, quarter hour and so on, until reading the clock on any reading was possible. This is largely a matter of counting beyond the multiples of five. The second method, identified as Method B, was based on the proposition that reading a clock was just a matter of memorizing numbers for the positions. Analog clocks were used with both groups. Nibbelink and Witzenberg

felt in 1981 that even though digital clocks were becoming very common, most clocks encountered by students would be analog clocks, so digital clocks were not used in this study.

Mean pretest and post test scores were determined for both groups. The treatment consisted of an eight day instructional program using textbook materials. Both groups made significant gains from their pretest to their post test, with Method B showing a slightly greater gain. Several recommendations were stated, to help the students master the skills needed to correctly tell the time. Among them were (1) stress the skill of counting by fives and (2) teach phrases such as "on the hour," "a little after the hour," "half-past," and "a quarter till" (Nibbelink and Witzenberg, 1981). All of these recommendations can only be applied to an analog clock.

The third and final study (Creedmore, "et al," 1985) deals with a direct comparison between digital and analog clock faces. The study was not a formal research study, but rather a review of the benefits of the digital method versus the analog method of teaching students how to tell time. The authors felt the analog clock appeared to be "busy," because it contained too many numerals, which could distract or confuse the

students. To read an analog clock face one must focus only on the numerals to which the hour and minute hands are pointing at that particular instance. In contrast the digital clock face displays just those numerals that are required to determine the exact time. Therefore, the digital clock helps eliminate many of the frustrations and difficulties an analog clock presents. These writers believe that the set of abstract time concepts represented by the analog clock, could be reduced to components of simplicity and direct utility, by using the digital clock. In other words, rapid developments in electronics, symbolized by the digital clock have provided methods for telling time more easily.

The authors felt that by utilizing a digital clock in the classroom, along with posting digital schedules, and sequenced murals of the school day's activities around the room, the students could begin to master the skills needed to read and understand a digital clock. In conclusion, they state that the technique of using a digital clock and requiring the students to learn just basic numeral recognition skills, will lead the students to become efficient and effective time-tellers. These authors came to an interesting

conclusion. However, just because their students recognized and read a set of numerals, does not necessarily mean they understood what those numerals meant. Students need to understand that a clock is really a measuring device, much like their rulers and meter sticks.

Many varied approaches have been implemented to assist educators in teaching the concept of telling time. Most of these methods have been used within the lower elementary mathematics class. Care should be taken not to limit these activities to just the lower elementary grades, as many of them would fill the same need in the upper elementary classroom.

One of the most interesting activities that involves the mathematics class, would be the introduction of a sundial. The sundial, with the changing position of the sun's shadow, gives the students a good illustration of the passage of time (Thompson and Van de Walle, 1981). The sundial also looks like a circular analog clock face; this is especially true when numerals are placed in their corresponding positions in relationship to the shadow of the sun at various times of the day. Sundials can also be constructed from the following materials; a

thick textbook, unlined paper, a pencil and a small amount of clay. The most important facet to remember is to relate the telling of time to the passage of time, and also relate these time referents to the events in the students' daily lives (Thompson and Van de Walle, 1981). This demonstrates to the students that different types of clocks can measure time accurately. This activity provides a nice introduction to comparing analog and digital clocks. Markle (1983) suggests that the teacher begin with a calendar clock, then proceed to a sand-filled timer, next a student's pulse rate, a water clock, and finally a pendulum. Even the phases of the moon, leap year, and the solar year could be discussed as time measuring devices. This activity or unit could end by researching atomic clocks; the possibilities are endless. For example, mathematics students could construct charts on how they spend their time during a typical school day, or use a parking meter to study how it measures the passage of time. With a little imagination the measuring of time could be incorporated into a great number of mathematics activities.

A linear clock is a special type of clock that is used to help students that are having difficulty

understanding the passage of time. A linear clock is basically a number line with time intervals marked off in both hours and minutes. An object (cart) is moved along the time line at a uniform rate to indicate that time is indeed being measured. Furthermore, displaying time intervals as distances ties in with the students' intuitive notions of time (Piaget, 1969). Schultz (1979) concludes that the linear clock may provide the concrete experience necessary for learning to use the more common clocks. Linear clocks could even be produced by the upper elementary students for the lower elementary classrooms, and become a learning experience for all students.

Two studies (Maertens, 1980; Nelson, 1982) have concluded that a twelve hour clock is one of the most effective methods of teaching the basic concept of telling time. The twelve hour clock is very familiar to all students and it does divide the day into twelve standard time segments. It is interesting to note that in one of these studies the digital clock is not mentioned at all and in the other study it appears only in the last two columns on the last page.

Maertens and Nelson each followed the same basic scope and sequence of instruction for developing the

ability to tell time. Both instructional programs began with a blank circular clock face. In the first activity the students were to place the twelve numerals in their correct positions. In the next step the hour hand was introduced, along with its function on the clock face. After the students had mastered the hour hand, the minute hand was introduced. Its function was also demonstrated for the students. Speed and direction of both hands were also discussed at this step. Finally, different time intervals were introduced, first counting by fives, and then by ones. This final step led directly to reading the exact time shown on the clock face. This is also the place where digital clocks were mentioned. They were shown side by side with an analog clock displaying the same time. It was stated that a digital clock is another type of clock used to tell time, but it was not actually used to help teach the ability to tell time. Nelson (1982) notes that the skill of telling time is actually an incorporation of the tactile sense along with the visual and auditory senses. He states that the analog clock does the most efficient job of incorporating these senses into the concept of telling time.

These methods, techniques, and activities are a few that are available to educators to help them teach the concept of telling time in their mathematics classes. The most prominent clock face used, with all these activities, was the analog clock face. In fact, the digital clock was never used at all to help develop the concept of telling time. It was used only as an example, of a new type of clock face.

Analysis of Mathematics Instructional Materials

The concept of telling time is usually developed in mathematics class. Therefore, the type of clock face found in the mathematics instructional materials will have a profound effect on the students' ability to understand how to tell time. To determine what type of clock face is being used, current mathematics instructional materials were examined.

Three major mathematics programs were selected for study. All three programs have a 1987 copyright date. The publishers of the three programs are: D. C. Heath Co., Harcourt Brace Jovanovich, Inc., and Modern Curriculum Press, Inc. Grades kindergarten through six were examined for each program. D. C. Heath and Harcourt Brace Jovanovich were chosen, because both are two of the top basal mathematics programs being used in

American classrooms today. Modern Curriculum Press was chosen because it is frequently used as a supplementary program by the resource room teacher, or used for extra drill and practice by the regular classroom teacher. Only the 1987 edition of Modern Curriculum Press was available. D. C. Heath editions from 1972 to 1987 and Harcourt Brace Jovanovich editions from 1966 to 1987 were analyzed. This was done to discover when the digital clock first appeared in these materials, if it appeared at all.

Each lesson was examined, even the non-time lessons were examined, to determine what percentage of the lessons used an analog clock face, a digital clock face, or a combination of both. The digital clock first appeared in the 1979 edition of the D. C. Heath series, and the 1978 edition of the Harcourt Brace Jovanovich series.

Any page that contained a digital clock, or an analog clock and a digital clock, was counted as a digital page. Any page that contained just an analog clock was counted as an analog page. This procedure was used for all three programs. The totals of each type of clock page were calculated as a percentage of

the total number of all pages that contained a clock face.

Table 1

Percentages of Analog Clock Pages and Digital Clock Pages

Series	Edition	Digital	Analog
D. C. Heath	1987	16%	84%
	1983	17%	83%
	1979	12%	88%
Harcourt	1987	21%	79%
Brace	1985	47%	53%
Jovanovich	1981	10%	90%
	1978	38%	62%
Modern Curriculum Press	1987	100%	0%

It appears from these findings that the authors of the D. C. Heath series feel the digital clock should be presented as a type of clock, not necessarily as the major example of how to measure time. The Harcourt Brace Jovanovich series follows about the same trend,

except for the 1985 edition. This edition was probably not well received; they had another revision two years later in 1987. It appears that the authors of the Modern Curriculum Press series feel that the digital clock is very important; it appears in all of their lessons that deal with time. Two sets of time flash cards were also examined. They were Ed-U-Cards, Telling Time Flash Cards, 1986 and Time Flash Cards, 1987; both sets devoted 50% of their cards to the digital clock face. This demonstrates that they, like the authors of the Modern Curriculum Press series, feel that the digital clock is important.

The type of clock face found in mathematics instructional materials is extremely important. Most educators feel that systematic instruction is necessary if students are to develop the concept of telling time (Burton and Edge, 1985). The most obvious location for this systematic instruction would be in the standard mathematics curriculum. While mathematics concepts are abstract in nature, real objects are frequently used by the students to help them understand those concepts. The clock face becomes the concrete example. It seems apparent that some major publishing companies have decided to utilize the analog clock face a majority of

the time. Burton and Edge (1985) state that since we live in an age of two types of common timepieces, students must learn from both. Teaching time using just a digital clock, will not solve all the problems; it appears that a combination of both types of clock faces is the best solution.

Summary and Conclusions

The digital clock is definitely here to stay and is becoming more and more common. By 1982 half of all the clocks and watches sold in the United States were digital, and experts keeping an eye on the timepiece industry predict that by 1990 the sale of digital timepieces will surpass 90% (Epiegram, 1983). These facts clearly indicate that educators need to find ways to include the digital clock in their classrooms. It appears they have little choice.

Does the type of clock face really influence the student's ability to tell time? Yes. A student needs to experience time, not just read a set of numerals. Helping students develop a concept of time, involves much more than teaching them to read the time from a clock face (Burton and Edge, 1985). The concept of time really includes the concepts of sequence and duration. Both need to be experienced thoroughly.

This can also lead to the development of a better self-concept on the part of the students. Students that can successfully tell time will have a greater sense of control over their lives (Britton, 1981).

Research indicates that the digital clock has not been used exclusively to teach students how to tell time. In every case the analog was introduced first and the digital clock was introduced later; it was never displayed alone. Even Jeffers (1979), when advocating the use of the digital clock to teach the telling of time, presented it simultaneously with the analog clock. Many students can read these digital clocks but do not possess a clear concept regarding the passage of time. A sound educational program, is obligated to teach students about the passage of time as they learn to read clocks (Thompson and Van de Walle, 1981). It is apparent that the analog clock face is still preferred by educators as the most effective device for teaching students how to tell time.

The method used the most often to help students best learn the concept of time was the three stage method presented by Burton and Edge (1985). In fact it was the only method utilized in all cases studied.

Those three stages are: (1) develop an understanding of the concept, (2) use relevant non-standard measures, and (3) use universally accepted standards of measure. Burton and Edge (1985) go on to state that before a student can or should read time from a clock face they should develop a concept of time. This does involve more than just teaching them to read numerals from a clock face.

This method was also employed by all three standard mathematics programs surveyed. An analog clock face was used in all teaching situations implementing this three stage approach. Also, all situations that employed the hour, half-hour, etc. to minute approach to telling time used the analog clock face. The movement of the hands became a very important segment of these lessons; a segment that could not be implemented with a digital clock face. It is apparent that the most effective method used and proposed by educators and researchers employs the analog clock face. Without the analog clock face and the hands found on it, most educators would be forced to teach numeral recognition instead of teaching the concept of time.

Some publishers of mathematics instructional materials have recognized this preference by educators. In two widely used basal mathematics programs, the D. C. Heath, 1987 edition and Harcourt Brace Jovanovich, 1987 edition, analog lessons out number the digital lessons about four to one. One exception to this trend is the 1987 edition of the Modern Curriculum Press mathematics program, a widely used mathematics supplementary program that uses the digital clock in all of its lessons dealing with time. These results provide the best evidence yet that educators prefer the analog clock face to teach students to tell time and that they use the digital clock face only as a secondary teaching device. Publishing companies are in business to make money. They do this by responding to the needs and wants of their customers--the classroom teachers. At the present time classroom teachers prefer the analog clock face and believe it is still the most effective device for teaching students how to tell time.

References

Britton, R. A. (1981). Teaching how to tell time. Academic Therapy, 16(4), 409-414.

Burton, G., & Edge, D. (1985). Helping children develop a concept of time. School Science and Mathematics, 85(2), 109-120.

Creekmore, W. N., Peters, L. H., Maxwell, R. C., Hunt-Lewis, D., Smith, A. L., & White-Roberts, M. (1985). Applied digital method: Alternative to analog. Academic Therapy, 21(2), 243-249.

Horak, V. H., & Horak, W. J. (1983). Let's do it, teaching time with slit clocks. Arithmetic Teacher, 30(5), 8-12.

Jeffers, V. (1979). Using the digital clock to teach the telling of time. Instructor, 26(7), 53.

Lovell, K., & Slater, A. (1960). The growth of the concept of time: A comparative study. Child Psychology and Psychiatry, 1(3), 179-190.

Maertens, N. (1980). Using an hour clock to teach time. Arithmetic Teacher, 27(7), 38-39.

Markle, S. (1983). Time out for measuring time. Instructor, 93(3), 142-144.

Nelson, G. (1982). Teaching time-telling. Arithmetic Teacher, 29(9), 31-34.

Nibbelink, W. H., & Witzenberg, H. H. (1981). A comparison of two methods for teaching younger children to tell time. School Science and Mathematics, 81(5), 429-435.

Perry, B., & Obenauf, P. (1987). The acquisition of notions of qualitative speed: The importance of spatial and temporal alignment. Journal of Research in Science Teaching, 24(6), 553-565.

Piaget, J. (1969). The child's conception of time. London: Routledge and Kegan Paul.

Riley, J. E. (1980). It's about time. Arithmetic Teacher, 28(2), 12-14.

Schultz, K. (1979). Linear clocks. Arithmetic Teacher, 26(7), 40-41.

Springer, D. V. (1952). Development in young children of an understanding of time and the clock. Journal of Genetic Psychology, 80, 83-96.

Staff. (1983). Time out of mind, the passing of the analog on the wall. Epiegram Equipment, pp. 5-6.

Stephens, L. & Dutton, W. H. (1969). The development of time concepts by kindergarten children. School Science and Mathematics, 69(5), 59-63.

Thompson, C. S. & Van de Walle, J. (1981). A single-handed approach to telling time. Arithmetic Teacher, 28(8), 4-9.