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An Investigation in the Use of Memorizing as a Learning Method When Teaching Measurement in a Technology Education Classroom

Joseph R. Porter
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AN INVESTIGATION IN THE USE OF MEMORIZATION AS A LEARNING METHOD WHEN TEACHING MEASUREMENT IN A TECHNOLOGY EDUCATION CLASSROOM

By

Joseph R. Porter

Plan B paper submitted in partial fulfillment

of the requirements

of

Master of Science

In

Technology and Engineering Education

Approved:

Dr. Gary Stewardson
Major Professor

Dr. Edward Reeve
Committee Member

Dr. Brian Warnick
Committee Member

UTAH STATE UNIVERSITY
Logan, Utah

2014

CONTENTS

Page

CHAPTER I

INTRODUCTION:

The Utah State Office of Education (USOE) has indicated in the objectives for many courses that students need to be able to identify measurements on a conventional ruler including 1/2, 1/4, 1/8, and 1/16-inch increments (Utah State Office of Education Career and Technology Education Division, 2012, p. 2). This objective is present in Career and Technical Education (CTE) Introduction, a required class for all Utah seventh graders, and is repeated in most of the CTE Technology and Engineering courses offered in the state. In conference with many other technology teachers, it has been observed that although they have taught this curriculum for years, they continue to observe that the student's level of retention is low. They always have to reteach the measurement lesson in each of the successive technology education classes the student's take. Some students have taken many courses that contain this instruction and yet they still seem to struggle to be proficient in meeting this objective. In an effort to align curriculum between the high schools and junior high schools in the Alpine School District in Utah, vertical alignment meetings were held. In the area of CTE Technology and Engineering, and Skilled and Technical Sciences, it was determined that one of the skills students entering high school lack is the ability to measure accurately. These students are being taught year after year and they are not retaining the knowledge.

The concept of measurement has been taught for years using different techniques, most of which focus on teaching students to understand the inch. These efforts introduce the student to the inch's anatomy. They are taught about the basic divisions from 1/16" to 15/16" and everything in between. The students are shown how each of the divisions in the inch is equal and how to reduce fractions. Great effort has been spent creating new and clever ways of helping students not only understand the concept of the inch, but to know everything about it. Students are often taught the origin of measurement and the reason it is essential in their lives. Connections are made to their lives and opportunity is given them to apply the skill through measurement activities. Bloom identified the level of application in the cognitive domain of learning as a more effective level of learning because students are able to make connections to the newly gained knowledge. This conceptual method is intended to teach the students so much about the inch that they cannot help but know how to measure. Students have been able to represent an understanding of measurement on assignments, however the long-term retention of this skill seems to be lacking. Days or weeks after being taught to measure, there is an apparent loss of ability to measure as the students are expected to use this skill to complete projects. Garii (2002) states that "information could be memorized yet not become knowledge. However, if information was not memorized, it could never become knowledge" (p. 1). The question then arises, will teaching the students how to measure through memorization lead to knowledge, and will they better retain that knowledge?

Students are taught how to measure throughout elementary, junior high, and high school. Measurement is taught in CTE courses as well as in science classes, and yet students continue to graduate not knowing how to measure. Measurement is a part of living. Knowing how to measure can provide an individual with a skill that can facilitate many aspects of their lives. Once a student graduates from high school they will not likely encounter another classroom experience where measurement is taught. This leaves them in a position where they will have to learn it on their own or continue as uninformed citizens.

Statement of the Problem:

Is there a place for memorization as a learning method when teaching measurement skills to middle school students in Utah?

Purpose:

With respect to the inch, there seems to be a disconnect between the learning about the skill of measurement, and the conversion of that skill into functional knowledge. Students know about the inch but they cannot measure. The purpose of this research project was to determine if focusing the student's effort on memorizing the fractions of an inch would increase their ability to convert their learning into functional knowledge. Would memorization help the students be able to retain the skill of measurement better than if memorization were not involved? Would memorization provide the students with the recall necessary to accurately measure for their projects in class?

<u>Objectives:</u>

1. Provide instruction to one group using the traditional conceptual understanding method as described above.
2. Provide worksheets and assignments that stress repetition to encourage memorization to a second group.
3. Collect data in a pretest and posttest design to identify if there is a difference in learning between the groups.

4. Collect data from a delayed posttest in the grading period without any further instruction on measurement to determine longer-term retention.
5. Compare data from the later post-test between groups to identify if there is a more effective way to teach measurement.

Research Questions

The following questions were used to guide the project:

1. Do students learn to identify the fractions on a ruler better when they are taught through the conceptual understanding method or through memorization?
2. Do the students retain the ability to identify the fractions on a ruler better when they are taught through the conceptual understanding method or through memorization?

Limitations

The following limitations were inherent in this investigation and may not be applicable to other non similar groups:

1. This investigation was limited to using two teaching methods, a conceptual understanding method, and a memorization method.
2. This investigation was administered to students in 7th grade who are enrolled in CTE Introduction and attend Frontier Middle School in the Alpine School District in the state of Utah.
3. This investigation was limited to measurement on a standard inch ruler.

Assumptions

The following assumptions were made in the planning of this project:

1. Students would answer the questions on the pretest, posttest, and delayed posttest honestly and to the best of their ability.
2. Students would have similar exposure to measurement practice outside of class time.
3. The instrument used to measure the student's ability to identify measurements on an inch ruler was effective and non-biased.

Procedure

The following procedure was used in conducting this study:

1. Reviewed the literature.
2. Identified the problem.
3. Developed a purpose.
4. Created lesson plans. (See Appendices A-D)
5. Developed assessment instrument. (See Appendix E)
6. Delivered instruction.
7. Administered assessments.
8. Gathered data.
9. Formulated conclusion.

Definition of Terms and Acronyms

1. USOE- Utah State Office of Education
2. CTE- Career and Technical Education
3. CTE Introduction- Career and Technical Education Introduction. This is a course required of all students in the state of Utah. Each student is exposed to lessons designed to increase their self-knowledge, career awareness, and career possibilities in technology, engineering, family and consumer sciences, business, information technology, manufacturing, marketing, agriculture, communications, and economics. The USOE has indicated in the standards for this course that measurement is a key component.
4. Vertical alignment- junior high school and high school teachers in like areas work together to create a curriculum that compliments each other. The goal of vertical alignment is to provide a pathway into further learning without any voids.
5. Conceptual understanding method- in this project, the term conceptual understanding method referred to teaching the students about the inch. The lesson was taught to the students through a discussion supported by a digital presentation (See Appendix D.). The students were introduced to this lesson with a short example of the importance of standardized measurement. One student with a large foot was asked to pace the width of the room. That student gave the number of paces to a student with a smaller foot who took that same number of paces, and the class discussed why the measurements were different. This lesson taught the students to recognize the equal

divisions within the inch. The presentation guided the lesson and showed the students how each line in the inch represented a different fraction. They were taught about the numerator and denominator and what they represented in the inch. The students were shown that the size of the lines within the inch carried common meaning. Students used a piece of paper and folded it and labeled each fold to represent the fractions of the inch. They were then able to use that reference inch in a guided practice experience on the presentation. (For application in this project see Appendices A-D.)

6. Memorization method- in this project, the term memorization method referred to the following method. Students were given a worksheet with a graphic of an inch with each fraction indicated for them. They were then given numerous blank inches and were expected to copy from the original. This repeated copying assignment increased the possibility that they would memorize the divisions of the inch. The students were given this same assignment at the beginning of five consecutive classes to practice the divisions of the inch. (For application in this project see Appendix C)

CHAPTER II

REVIEW OF LITERATURE:

To an individual who uses measurement in their everyday life, it is hard to comprehend that children enter middle school unable to read a ruler. Students complete their elementary schooling experience without the necessary knowledge to determine the size of their diploma. This lack of knowledge puts them at a disadvantage in their life, and many are unable to demonstrate even a basic understanding of reading an inch in middle school. In the state of Utah each seventh grade student is required to take a course entitled Career and Technical Education Introduction (CTE Introduction). One of the objectives of this course as indicated in the standards published by the state is to "demonstrate the ability to use measuring tools to measure accurately to 1/16" (Utah State Office of Education Career and Technology Division, 2010, p. 11). These course objectives have been written to guide the teachers in what they need to teach. There is an expectation that measurement be taught, but it is also expected that the students will not need to spend much time on measurement to demonstrate understanding. This expectation is based on the belief that the students have a foundational understanding of measurement when they enter into middle school. This is not the case, so measurement becomes an important lesson that the students begin to learn in seventh grade.

Measurement has been taught in the junior high schools starting in the CTE Introduction class to all students in the school and then thereafter to each student who takes the follow-up classes in eighth and ninth grades. Teachers have been teaching students to measure for years, yet the students do not seem to retain what they have learned. Measurement has been taught in such a way that the students are taught the origin of the inch, the importance of standardized measurement, and how each line has a meaning. The students learn about the numerators and denominators of each of the fractions and why they have their respective numbers. This method is referred to as the conceptual understanding method. The student's lack of understanding may not be the fault of the student. The inability to apply the knowledge may be a result of a change in the way students are expected to learn. At some point in the past a concept that used to be a part of every students learning routine became taboo. Students used to be expected to spend long hours practicing multiplication tables until they had them memorized. "For more than a decade, students as young as kindergartners have been encouraged to use calculators rather than computation; memorization, even of multiplication tables, has been spurned" (Hartocollis, 2000, p. 1). This concept is even being perpetuated in college. Miller, Perrotti, Silverthorn, Dalley, and Rarey (2002) said, "the reality that memorization is not understanding is a concept that must be repeatedly emphasized in undergraduate courses" (p. 72).

What is the most effective way to help students gain knowledge? In a study where students were asked to identify the ways they recognized knowledge and how to gain it, they indicated that memorization was the primary method for bringing learning into knowledge. They further indicated that although memorization was not liked, knowledge was unobtainable without memorizing the basic parts of a concept (Garii, 2002, p. 10). Maybe a return to the expectation of memorization will make it possible for the student to learn concepts in math and concepts related to math such as measurement. "Memorization is a key cognitive process of the brain because almost all human intelligence is functioning based on it" (Wang, 2009, Abstract).

Learning is a process that must follow certain steps. Just as a building cannot be erected from the top down, knowledge must be gained from the bottom up. Foundational principles must be obtained and made concrete before more knowledge can be built upon them. In math, addition and subtraction are basic skills that a student must master before they will be able to master more complex problems (Bielsker, Napoli, Sandino, and Waishwell, 2001). As new pedagogical methods are developed and deployed in the public education system, some previously valued techniques have been forgotten or put aside. Teachers have moved past the task of memorization directly to the task of teaching conceptual understanding, the technique of helping students learn about a concept and directing them to make connections with the knowledge. This has proven to be a valuable teaching method and is widely accepted to be better than memorization. This has created a void in the student's ability to learn and retain knowledge. Garii (2002) discovered that students "suggested that memorization and conceptualization work symbiotically and the 'aha' experience occurs when the learned material becomes a usable and internally explainable concept" (p. 10).

Learning seems to be more that just knowing about something. It is the process of memorizing foundational facts and then connecting those facts to real life experiences. "Indeed it is believed that memorization itself is not a tragic or bad practice, and the beauty of memorization appears when the memorizer tries to understand what he has memorized"(Yusuf, 2010, p. 1). Students need teachers to direct them to apply their knowledge. The importance in the conceptual understanding teaching method lies in the making of connections with the knowledge that the students learn through memorization. "Having reasons for a task facilitates understanding, so it helps to give students reasons why an approach of reasoning is better and why memorization is not the same as understanding" (Miller et al. 2001, p. 72). Students need to learn first and then transfer that knowledge into something that matters to them. This connection is commonly referred to as transfer. In Blooms taxonomy, transfer is indicated as a higher level learning method than memorization. Although transfer does provide the student with a greater and more effective cognitive response it is not effective without memorizing the basic building blocks of that understanding. "Transfer is affected by the degree to which people learn with understanding rather than merely memorizing sets of facts or following a fixed set of procedures" (National Research council, 2004, p. 55).

The lessons on measurement that are being taught in junior high school technology and engineering classes have been well planned and well delivered.

Opportunities have been given to students to learn the skill of measurement and yet they are unable to retain what they learn. High school teachers have to reteach the students what they already should know. Technology teachers are able to make connections to the student's lives more easily than any other subject but the retention is falling short. Perhaps it is because of the fact that they have strayed from the basic building blocks of learning. Perhaps it is because the basic knowledge that the students need in order to apply and connect the knowledge that they are receiving has not been taught. Perhaps it is because they avoid memorization as a learning method because it is not popular any more. "Some researchers believe that there is too little emphasis on rote memorization. Although it is appropriate for teachers to address conceptual understanding of mathematics (measurement), it is equally important to focus on rote memorization strategies (Beilsker et al. 2001, p. 35).

There is a belief that memorization is important to the learning process, and there is a belief that conceptual understanding is a better way. Studies have indicated that learning is more effective when conceptual understanding is encouraged after the foundational principles have been learned. This research project provided one group of students with the opportunity to focus on memorizing the anatomy of an inch to see if the opportunities they had to use that memorized knowledge in the class, would allow them to retain that knowledge better than the group that was not expected to memorize. Research suggested that this would be the case.

CHAPTER III

METHODS:

The purpose of this project was determine if students would retain the ability to measure throughout the length of the course better when taught through the traditional conceptual understanding method, or through exercises in memorization. The length of the course was 45 days, so the researcher began this lesson on the first day of class. This ensured that there would be a sufficient delay before the delayed posttest. Each group was given a short introduction to proper, improper, and mixed fractions to ensure that they were being tested on their ability to measure, and not their ability to write a fraction correctly. The researcher wrote an example of a proper fraction on the whiteboard and explained that the numerator was smaller than the denominator. He then wrote an improper fraction on the board and explained that in that fraction the denominator was smaller than the numerator. A brief discussion was had instructing the students that their answers should always be written as proper fractions. The instructor then wrote a mixed fraction on the board and the students were instructed that they could also write a fraction in a mixed format as long as the fraction was proper.

Following this very brief explanation of fractions each group was given a pretest to determine the level of knowledge they already had. Following the pretest, one group of students was taught how to measure using the traditional conceptual understanding method described in the treatments section below. The lesson was delivered and timed using a stopwatch. The lesson took 60 minutes to teach. Careful attention was given to make sure that the students in the memorization group were afforded the same amount of class time to complete their learning. The decision was made to give the students 12 minutes at the beginning of five consecutive class periods to complete the memorization assignments. Students then participated in the regularly scheduled activities and lessons for the duration of the period. This removed any advantage that increased time would have offered the students of either group.

At the completion of the unit of study, the students of each group were given a posttest, which was identical to the pretest. After the posttest was scored, the results from the pretest were compared to the scores from the posttest to determine the student's level of improvement. The results acquired at this point represented the increase of knowledge gained through each method of instruction. Although this information was important and answered the first research question, the second research question of this research project required more information. The second research question of the research project was to ascertain which method of instruction would lead the students to be able to retain the newly gained knowledge better. The students were given a delayed posttest at the end of the class term. This delayed posttest, which was identical to the previous pretest and posttest, was given 30-35 days following instruction in an effort to identify the level of the student's retention.

Population:

The students chosen for this experiment were the students in the researcher's classes. The classes consisted of approximately 400 seventh graders and took place during their CTE Introduction class. The researcher taught many sections of this course and experimented with fourteen (N=14) of them. Half of them (N=7) were taught to measure using the conceptual understanding method, while the other half were given repetitious activities to support their memorization effort. The classes were assigned a certain treatment before the school year began to reduce the chance of bias.

CTE Introduction was chosen because it was a course required of all seventh graders in the state. Selecting this course provided a better sampling of students, and therefore provided a better representation of the effects of these two instructional treatments. Although this experiment could have been done with other courses in the junior high school, there was a higher possibility that the students in eighth and ninth grade would have already received measurement instruction. This could have potentially rendered the results of testing invalid, so it was decided to experiment with only seventh graders enrolled in CTE Introduction. The experimenter had each class for 45 days.

Study Resources:

This experiment required a few resources. Each treatment required an organized and limited lesson plan (See Appendices A, D). These lesson plans indicated to what extent the instruction was given and also included the worksheets and class activities. Each lesson had the same terminal objectives but contained different enabling objectives as the lesson format dictated. There was also a pretest, a posttest, and a delayed posttest. These tests were developed by the researcher and reviewed by other technology education teachers to determine its validity as an instrument to assess an individual's ability to correctly identify fractions on a standard inch ruler. It was determined to be a valid instrument.

In an effort to ensure that the instruction could be delivered as planned, the treatments were delivered to two different groups as a pilot. The implementation of the treatments in a pilot allowed for the improvement of the lessons and provided more information regarding the unplanned variables that were faced. The assessment instrument was also evaluated for consistency in its ability to measure a student's proficiency in identifying fractions on a ruler. Following the pilot, there were very few changes that needed to be made. The pretest, posttest, and delayed posttest were determined to be effective and were not changed.

Treatments:

This research project consisted of two treatments. One treatment focused on delivering instruction to teach the students to conceptually understand the inch, while the other treatment consisted of only worksheets, developed by the researcher, to provide the students with the opportunity to memorize the anatomy of the inch. These treatments were delivered during the second, third, and fourth terms of the school year. The classes were chosen for each treatment prior to the beginning of the research. The decision was made to follow an alternating pattern, where the first class was taught with one treatment and the next class was taught with the other treatment. This pattern continued through the term of the research.

Treatment 1:

Treatment 1 was the same lesson that has been used by the researcher for years. This lesson had been modified many times and closely resembled lessons taught by many junior high school teachers in the district. The lesson was taught to the students through a discussion supported by a digital presentation. The students were introduced to this lesson with a short example of the importance of standardized measurement. One student with a large foot was asked to pace the width of the room. That student gave the number of paces to a student with a smaller foot who then took that same number of paces. The class then discussed why the measurements were different. As the lesson continued, the students were taught to recognize the equal divisions within the inch. The presentation guided the lesson and showed the students how each line in the inch represented a different fraction. They were taught about the numerator and the denominator and what they represented in the fraction. The students were then shown that the size of the lines within the inch carried a common meaning. Students were then guided in an activity where they used a piece of paper and folded it and labeled each fold to represent the fractions of the inch. They were then able to use that reference inch in a guided practice experience on the presentation. Following the lesson, the students were given a brief worksheet, developed by the researcher in collaboration with other technology education teachers, to practice their measurement skill. The students were allowed to use the folded paper to assist them as they identified the measurements on the worksheet.

Treatment 2:

The students in the group identified for treatment 2 were given a worksheet that contained a graphic of an inch with each fraction identified for them. They were given numerous blank inches and were expected to copy from the original. This repeated copying assignment should have increased the possibility that they would memorize the fractions of the inch. The students were given this assignment at the beginning of five successive class periods and afforded 12 minutes to complete it. This group was not given instruction beyond the common discussion about proper, improper, and mixed fractions. This allowed for the results of their posttests to be a reliable data point to compare with the other research group.

The time it took to teach the conceptual understanding lesson as described in treatment 1 was 60 minutes. In order to provide each group with the same amount of class time spent on the instruction, it was decided to provide the group being taught using treatment 2 twelve minutes at the beginning of five successive class periods to complete the memorization worksheets. Students then participated in the regularly scheduled activities and lessons for the duration of the period.

Treatments 1 and 2:

Both treatments 1 and 2 began with the pretest developed by the researcher, and acknowledged valid by other technology education teachers. This pretest established a baseline to which each student's progress was then compared. The students were given the posttest following the period of instruction. The students in treatment 1 were given the posttest on the day after the completion of the 60 minutes of instruction. The students instructed with treatment 2 were given the posttest at the completion of the 60 minutes used to complete the memorization worksheets. The posttest was the same as the pretest and the data from the posttest was compared to the data rom the pretest to measure the student's increase in understanding (Tables 1-2). Research has determined that knowledge is only stored in short term memory for 30 days. At the close of the class term, following a gap of at least 30 days, a delayed posttest, which was identical to the pretest and posttest, was administered so that the data could be compared to the data from the posttest (Tables 1-2). This comparison represented the level of retention held by the students in each group.

Data Analysis Plan:

The results of this project were communicated using descriptive statistics. This project required that data be taken at three different times. Each student took pretest, a posttest, and a delayed posttest. These tests were graded and the results were recorded in a spreadsheet. The average percent correct was calculated for each test in each class and these results were used for comparison. The pretest average was compared to the posttest average to identify the value added through the instruction process. The posttest average was compared to the delayed posttest average to identify retention. The same procedure was followed to compare the posttest results with the delayed posttest results to determine the level of retention. These results are represented in Tables 1-3.

CHAPTER IV

FINDINGS

The following questions were used to guide the project:

1. Do students learn to identify the fractions on a ruler better when they are taught through the conceptual understanding method or through memorization?

Do the students retain the ability to identify the fractions on a ruler better when they are taught?

Table 1 contains the average scores earned by the students who were taught using treatment 1 on the pretest, posttest, and delayed posttest. The standard deviation has also been indicated as well as the class size for each group (N). The classes are numbered according to the order they were taught. This data indicates that class 6 was the only class that scored a higher score on the delayed posttest than on the posttest.

Table 1

Pretest, Posttest, and Delayed Posttest Results for the group taught using Treatment 1

Class	Pretest	SD	Posttest	SD	Delayed Posttest	SD
1(N=31)	55.72%	39.57	91.68%	18.04	89.7%	22.12
3(N=37)	59.7%	12.857	92.65%	16.3	91.93%	18.26
5(N=40)	52.5%	36.86	85.21%	24.43	83.1%	29.94
7(N=33)	56%	40.38	81.86%	32.85	81.41%	31.03
9(N=37)	64.61%	39.11	94.8%	11.73	86.1%	26.74
11(N=28)	56.25%	37.31	83.73%	26.02	90.26%	19.46
13(N=27)	58.37%	36.4	89.84%	22.21	79.75%	29.26

Table 2 contains the average scores earned by the students who were taught using treatment 2 on the pretest, posttest, and delayed posttest. The standard deviation has also been indicated as well as the class size for each group (N). The classes are numbered according to the order they were taught. This data indicates that every class except for class 6 scored a higher score on the delayed posttest than on the posttest.

Table 2

Pretest, Posttest, and Delayed Posttest Results for the Group Taught Using Treatment 2

Class	Pretest	SD	Posttest	SD	Delayed Posttest	SD
2(N=25)	68.1%	36.95	88.75%	23.72	88.2%	25.5
4(N=31)	45.46%	38.78	73.61%	37.88	77.31%	34.88
6(N=41)	45.2%	33.48	87.6%	25.44	88.7%	21.54
8(N=22)	60.08%	36.64	88.5%	25.83	91.3%	18.57
10(N=27)	76.4%	32.28	91.18%	19.64	96.23%	9.57
12(N=36)	44.61%	39.2	79.7%	30.75	74.4%	36.22
14(N=32)	51.7%	35.55	76.59%	32.13	87.4%	24.65

Table 3 contains the average scores earned by all students who were taught using each treatment on the pretest, posttest, and delayed posttest. The standard deviation has also been indicated as well as the total group size for each treatment (N). This data indicates the group that was taught using treatment 1 earned higher scores on average than the group taught using treatment 2 on the posttest. As expected, the data indicates that the scores from group that was taught using treatment 1 declined on the delayed posttest. What was not expected was that the data also indicates that the scores from the group taught using treatment 2 made a positive improvement on the delayed posttest. Despite the difference in the trends of both groups, their scores were actually very similar to each other on the delayed posttest.

Table 3

Cumulative Results from Pretest, Posttest, and Delayed Posttest from Groups Taught Using Treatment 1 and Groups Taught Using Treatment 2

Treatment	Pretest	SD	Posttest	SD	Delayed Posttest	SD
1 Conceptual Understanding (N=233)	57.39%	12.87	88.65%	7.59	86.46%	8.65
2 Memorization (N=214)	56.58%	12.85	83.74%	9.80	85.98%	9.16

CHAPTER V

CONCLUSIONS:

The following questions were used to guide the project:

2. Do students learn to identify the fractions on a ruler better when they are taught through the conceptual understanding method or through memorization?
3. Do the students retain the ability to identify the fractions on a ruler better when they are taught through the conceptual understanding method or through memorization?

The following calculation was used to determine the value added in each research group: $\overline{X}$ posttest percentage – $\overline{X}$ pretest percentage. Although both groups made large gains in their knowledge, the students in the conceptual understanding group were able to show a greater increase in their ability to identify the fractions on a ruler. They improved their scores on the posttest 4.1% better than the group who were taught through the memorization method.

The following calculation was used to determine the level of retention for each group: $\overline{X}$ delayed posttest percentage – $\overline{X}$ posttest percentage. These results were then compared to identify which group achieved the greatest retention. The calculation provided data to suggest that the group who was taught through the memorization method retained the ability to identify the fractions on a ruler 4.43% better than the group that was taught through the conceptual understanding method. In fact, the data shows that the students who were taught using the conceptual understanding method actually achieved lower scores on the delayed posttest than on the posttest. The opposite was the case for the students who were taught using the memorization method.

Summary

Based on the results that were described previously, students who were taught using the conceptual understanding method were able to score higher on the posttest than the group who were taught using the memorization method. This result answers the first research question, and by itself could be sufficient information to direct further teaching efforts. This data is impressive, however upon further analysis, it becomes apparent that although the students who were taught using the memorization method were not able to score as high on the posttest as the other group, the trend indicates that they continued to increase in knowledge and retention. The results of the delayed posttest show that these students increased in their knowledge while the students in the conceptual understanding group lost some knowledge.

Recommendations

Both teaching methods provide the students with information that helps the students increase in knowledge. The results of the testing suggest that for greater retention and knowledge acquisition, students would benefit more from the memorization method than the conceptual understanding method. Although the memorization method sets the student on a path for increasing their knowledge, the data trend suggests that it is possible that they acquire that knowledge at a slower rate than the conceptual understanding method.

Both methods help the students differently, and ought to coexist rather than exclusively be used. Students who would be taught through both methods could be given the immediate knowledge gained through the conceptual understanding method, which could give them the advantage they need to do well on the classroom activities. They could then have that knowledge reinforced and strengthened through exercises in memorization. It is recommended that both methods be used in order to achieve the greatest results. Students should be involved in memorization exercises as a lead-in to the conceptual understanding lesson. As the student is spending time memorizing the fundamental divisions of the inch, the conceptual understanding lesson will reinforce the need for this knowledge.

Further research would be needed to verify the hypothesis of the researcher that both methods combined would increase a students learning and retention. This research should be conducted with a similar population in the same geographic location.

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Appendix A. Conceptual Understanding Lesson Plan

CONCEPTUAL UNDERSTANDING LESSON PLAN

Terminal Objective: Read and identify dimensions on a standard ruler.

Performance Objective: Given a diagram of a standard ruler, read dimensions to 1/16th of an inch, using proper or mixed fractions in their lowest terms, with a minimum score of 90% correct.

Enabling Objectives:

1. Define the following terms: whole numbers, proper fractions, improper fractions, mixed fractions, numerator, and denominator.
2. Connect correct fractions to their locations on a standard inch.

Laboratory Hardware: None

Learning Activities:

1. Participate in PowerPoint Presentation, Measurement.
2. Fold and label a piece of paper to represent the divisions of an inch.
3. Complete Activity Sheet 1, Measurement.
4. Complete Measurement Post Test.

Formative Evaluation: The worksheet, Measurement, will be used as a practice assignment and will be used to asses student progress. The answers to Activity Sheet 1 are as follows:

a.	¼”	d.	1-9/16”	g.	3-15/16”	j.	5-9/16”
b.	½”	e.	2-3/8”	h.	4-1/16”		
c.	1-1/8”	f.	3-5/16”	i.	4-5/8”		

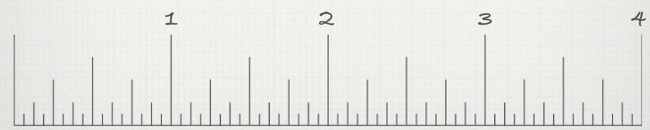
Summative Evaluation: Students will be given Post Test 1 at the end of the lesson. This assessment will be used to assess the performance objective for the lesson. The answers for the post-test are as follows:

1.	1-5/8”	10.	2-3/8”	19.	20-11/16”	28.	7/8”
2.	3”	11.	45-3/16”	20.	9-5/8”	29.	21-3/8”
3.	4-3/16”	12.	6-1/16”	21.	100-9/16”	30.	35-5/16”
4.	3-9/16”	13.	3-15/16”	22.	½”	31.	5-15/16”
5.	10-1/4”	14.	10-7/16”	23.	77-7/16”	32.	7-1/8”
6.	5-13/16”	15.	9-3/4”	24.	98-13/16”	33.	4”
7.	11”	16.	1-1/8”	25.	2-1/2”	34.	10-1/16”
8.	2-7/8”	17.	2-11/16”	26.	5-3/4”		
9.	8-5/16”	18.	4-1/4”	27.	2”		

Appendix B. Conceptual Understanding PowerPoint

MEASUREMENT

LET'S LEARN THE INCH

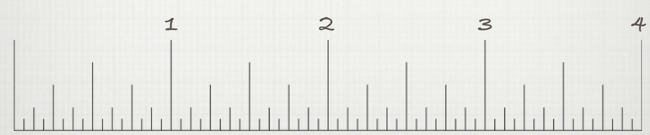


STANDARD

- USED IN UNITED STATES AND ALMOST NO WHERE ELSE.
- INCH, FOOT, YARD, MILE

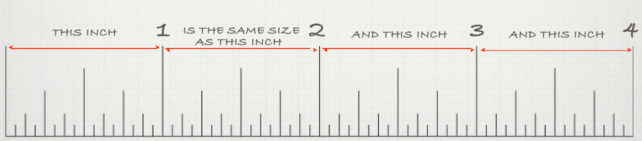
LET'S LEARN THE INCH

- Since the inch is always the same, all we need to learn is how one is made up.
- All we need to learn are 15 fractions that make up the inch.



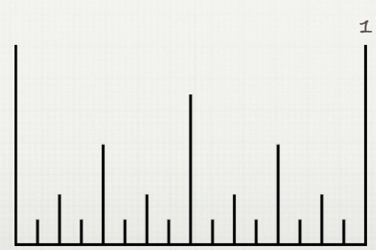
LET'S LEARN THE INCH

- THE INCH SHOWS UP ON A STANDARD RULER OVER AND OVER AGAIN.
- EACH TIME IT APPEARS IT HAS THE SAME MAKE UP.



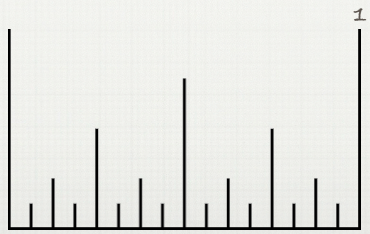
LETS LOOK MORE CLOSELY

- WHAT DO YOU NOTICE WHEN YOU LOOK AT THIS INCH?



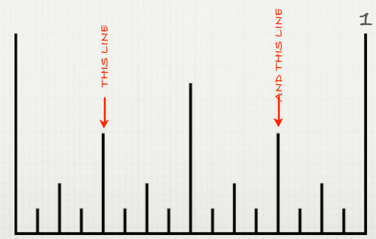
LETS LOOK MORE CLOSELY

- SOME OF THE LINES ARE THE SAME SIZE AS EACH OTHER



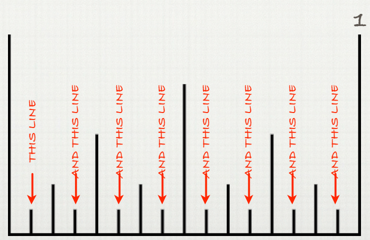
LETS LOOK MORE CLOSELY

- SOME OF THE LINES ARE THE SAME SIZE AS EACH OTHER



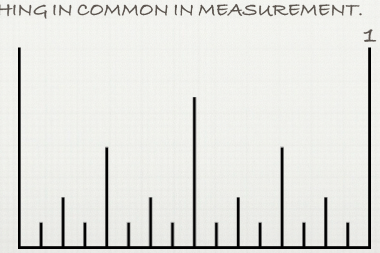
LETS LOOK MORE CLOSELY

- SOME OF THE LINES ARE THE SAME SIZE AS EACH OTHER



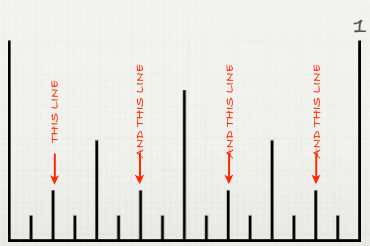
LETS LOOK MORE CLOSELY

- SINCE THEY HAVE THE SAME HEIGHTS, THEY MUST HAVE SOMETHING IN COMMON IN MEASUREMENT.



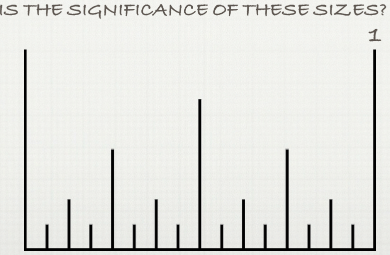
LETS LOOK MORE CLOSELY

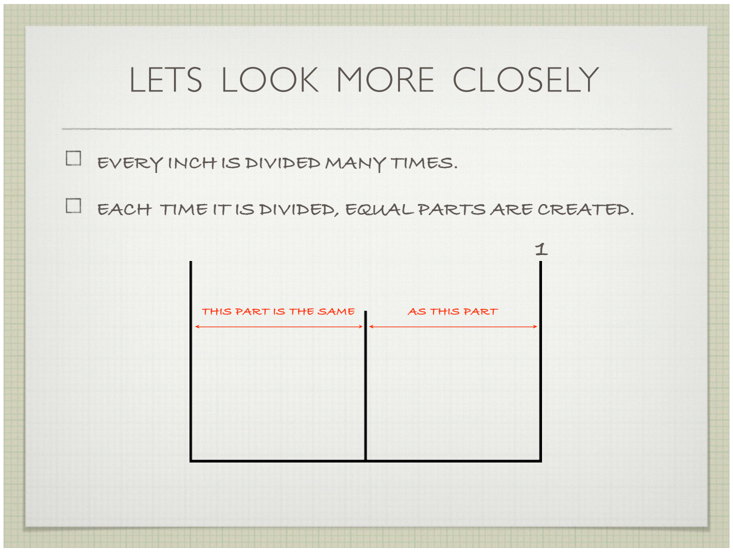
- SOME OF THE LINES ARE THE SAME SIZE AS EACH OTHER

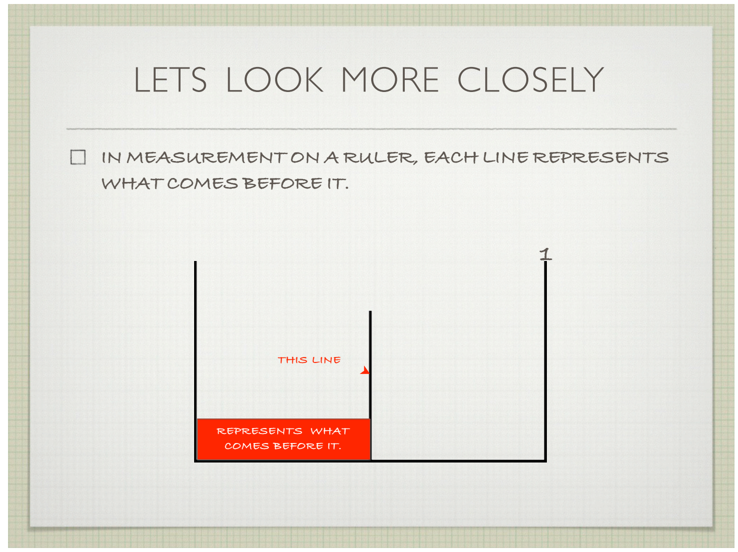


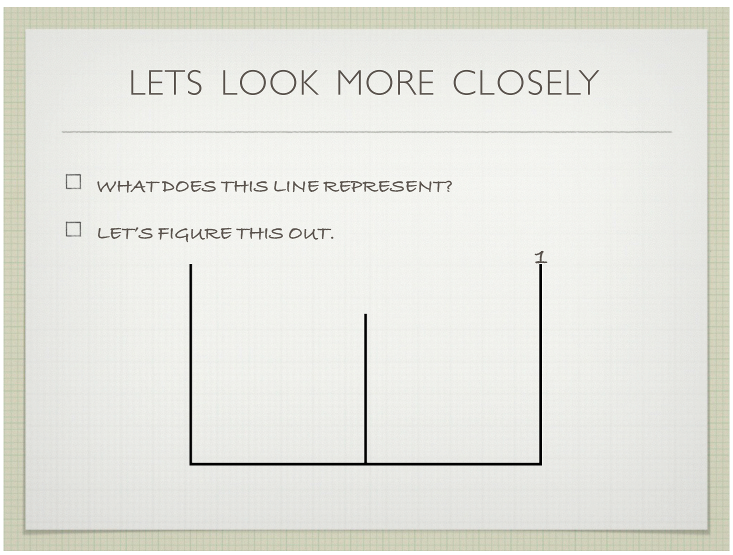
LETS LOOK MORE CLOSELY

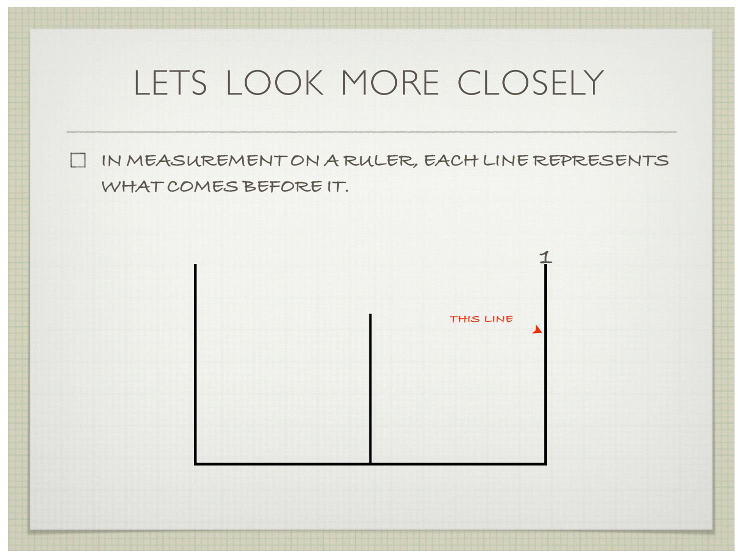
- WHAT DO THESE LINES MEAN?
- WHAT IS THE SIGNIFICANCE OF THESE SIZES?

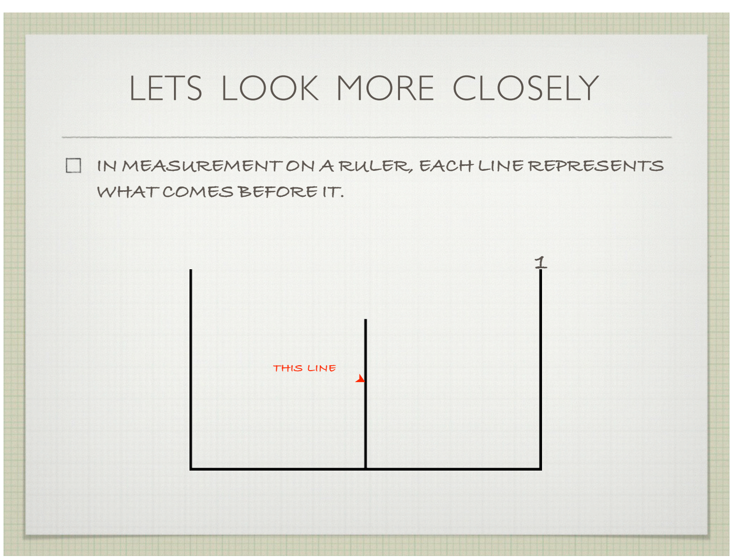


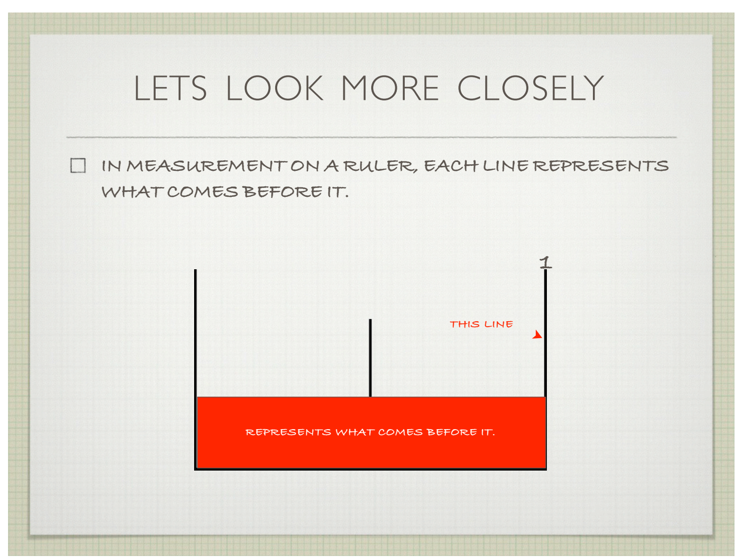

LETS LOOK MORE CLOSELY
EVERY INCH IS DIVIDED MANY TIMES.
EACH TIME IT IS DIVIDED, EQUAL PARTS ARE CREATED.
1
THIS PART IS THE SAME
AS THIS PART

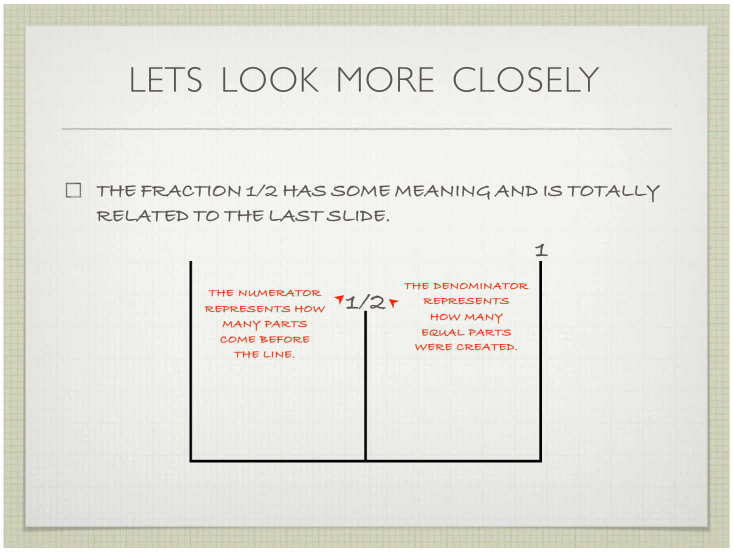

LETS LOOK MORE CLOSELY
IN MEASUREMENT ON A RULER, EACH LINE REPRESENTS WHAT COMES BEFORE IT.
1
THIS LINE
REPRESENTS WHAT COMES BEFORE IT.

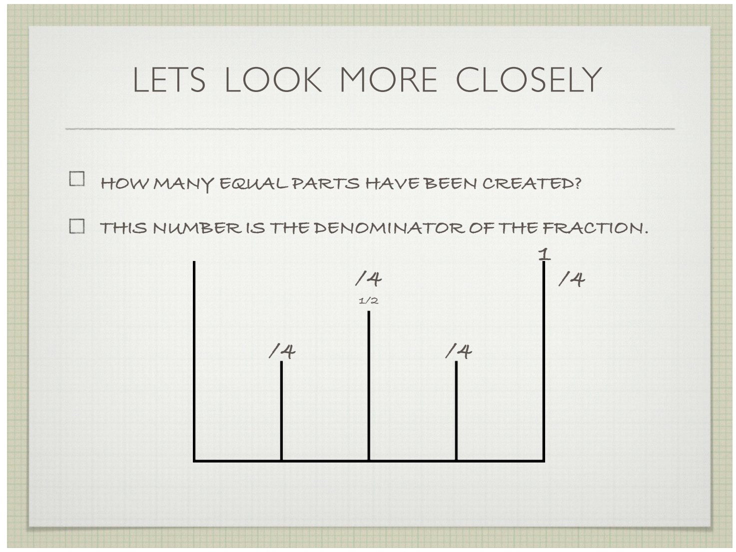

LETS LOOK MORE CLOSELY
WHAT DOES THIS LINE REPRESENT?
LET'S FIGURE THIS OUT.
1

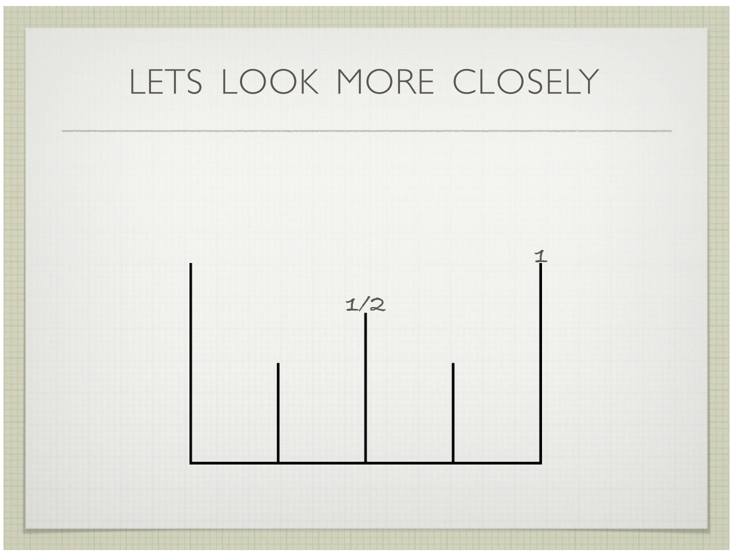

LETS LOOK MORE CLOSELY
IN MEASUREMENT ON A RULER, EACH LINE REPRESENTS WHAT COMES BEFORE IT.
1
THIS LINE

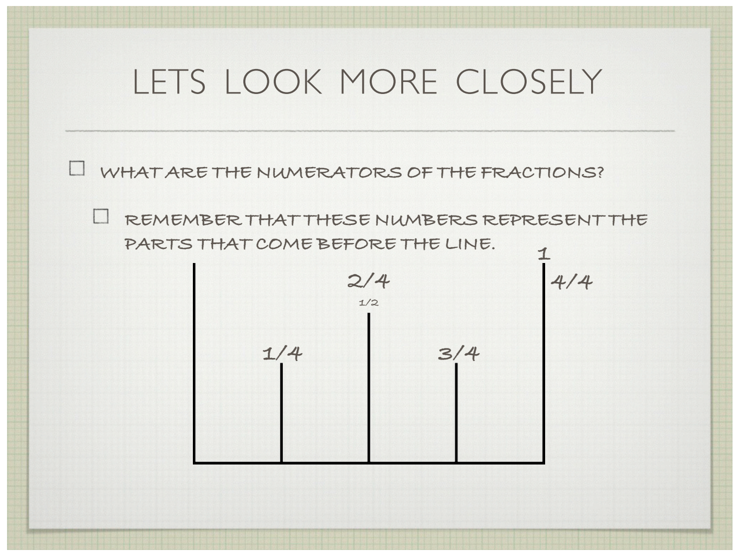

LETS LOOK MORE CLOSELY
IN MEASUREMENT ON A RULER, EACH LINE REPRESENTS WHAT COMES BEFORE IT.
1
THIS LINE

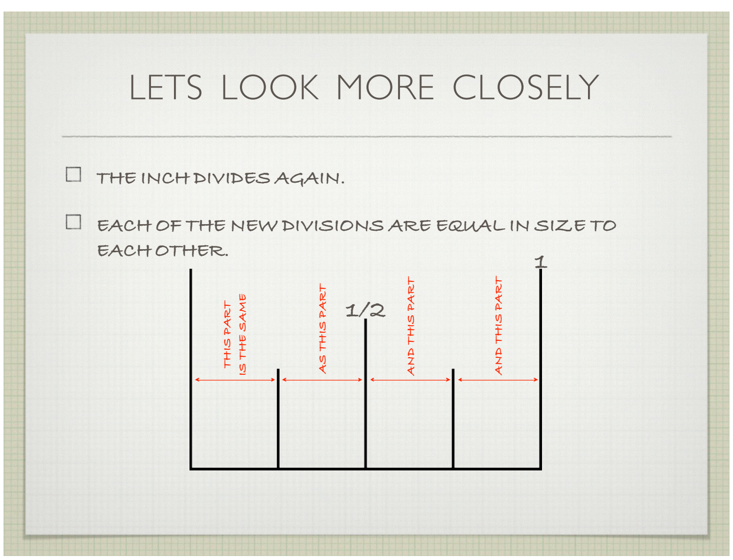

LETS LOOK MORE CLOSELY
IN MEASUREMENT ON A RULER, EACH LINE REPRESENTS WHAT COMES BEFORE IT.
1
THIS LINE
REPRESENTS WHAT COMES BEFORE IT.


LETS LOOK MORE CLOSELY
THE FRACTION 1/2 HAS SOME MEANING AND IS TOTALLY RELATED TO THE LAST SLIDE.
1
THE NUMERATOR REPRESENTS HOW MANY PARTS COME BEFORE THE LINE.
1/2
THE DENOMINATOR REPRESENTS HOW MANY EQUAL PARTS WERE CREATED.


LETS LOOK MORE CLOSELY
HOW MANY EQUAL PARTS HAVE BEEN CREATED?
THIS NUMBER IS THE DENOMINATOR OF THE FRACTION.
1
/4
1/2
/4
/4
/4


LETS LOOK MORE CLOSELY
1
1/2

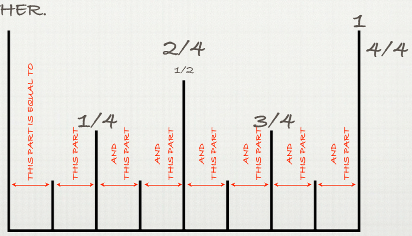

LETS LOOK MORE CLOSELY
WHAT ARE THE NUMERATORS OF THE FRACTIONS?
REMEMBER THAT THESE NUMBERS REPRESENT THE PARTS THAT COME BEFORE THE LINE.
1
2/4
1/2
4/4
1/4
3/4


LETS LOOK MORE CLOSELY
THE INCH DIVIDES AGAIN.
EACH OF THE NEW DIVISIONS ARE EQUAL IN SIZE TO EACH OTHER.
1
1/2
THIS PART IS THE SAME
AS THIS PART
AND THIS PART
AND THIS PART

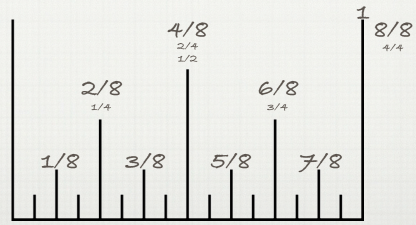

LETS LOOK MORE CLOSELY
1
2/4
1/2
4/4
1/4
3/4

LETS LOOK MORE CLOSELY

- THE INCH DIVIDES AGAIN.
- EACH OF THE NEW DIVISIONS ARE EQUAL IN SIZE TO EACH OTHER.



LETS LOOK MORE CLOSELY

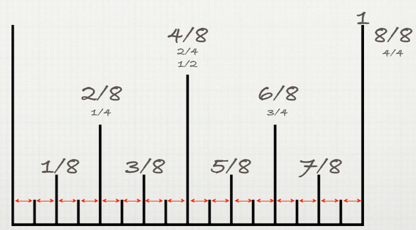


LETS LOOK MORE CLOSELY

- HOW MANY EQUAL PARTS HAVE BEEN CREATED?
- THIS NUMBER IS THE DENOMINATOR OF THE FRACTION.

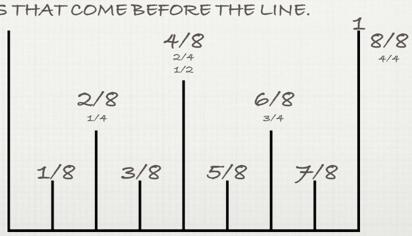
LETS LOOK MORE CLOSELY

- THE INCH DIVIDES AGAIN.



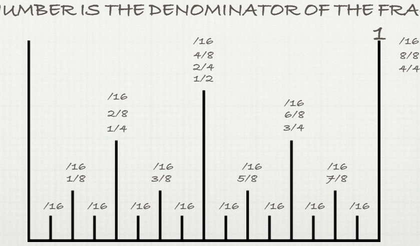
LETS LOOK MORE CLOSELY

- WHAT ARE THE NUMERATORS OF THE FRACTIONS?
  - REMEMBER THAT THESE NUMBERS REPRESENT THE PARTS THAT COME BEFORE THE LINE.



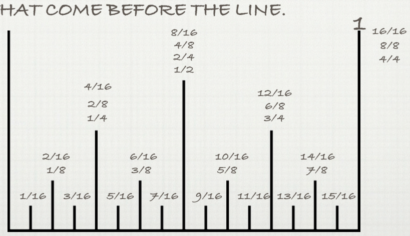
LETS LOOK MORE CLOSELY

- HOW MANY EQUAL PARTS HAVE BEEN CREATED?
- THIS NUMBER IS THE DENOMINATOR OF THE FRACTION.



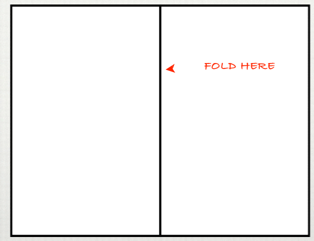
LETS LOOK MORE CLOSELY

- ☐ WHAT ARE THE NUMERATORS OF THE FRACTIONS?
- ☐ REMEMBER THAT THESE NUMBERS REPRESENT THE PARTS THAT COME BEFORE THE LINE.

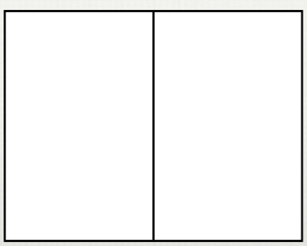


LETS MAKE A REFERENCE INCH

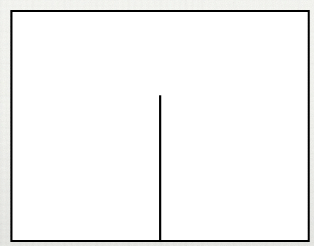
- ☐ TAKE A SHEET OF COPY PAPER
- ☐ FOLD IT IN HALF WITH THE SHORT SIDES TOGETHER.



LETS MAKE A REFERENCE INCH

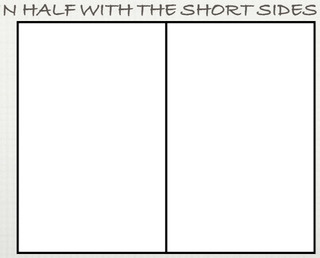


LETS MAKE A REFERENCE INCH



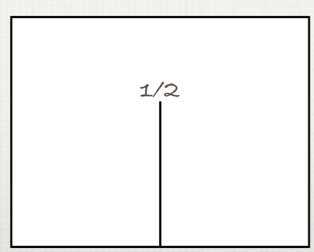
LETS MAKE A REFERENCE INCH

- ☐ TAKE A SHEET OF COPY PAPER
- ☐ FOLD IT IN HALF WITH THE SHORT SIDES TOGETHER.

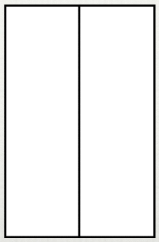


LETS MAKE A REFERENCE INCH

- ☐ OPEN THE PAPER AND MARK THE FOLD LINE WITH THE FRACTION 1/2.

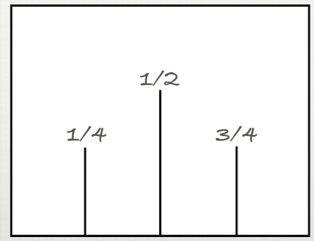


LETS MAKE A REFERENCE INCH



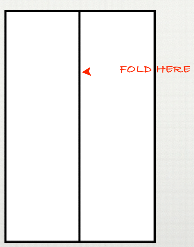
LETS MAKE A REFERENCE INCH

- ☐ OPEN THE PAPER AND MARK THE NEW FOLD LINES WITH THE FRACTIONS 1/4 AND 3/4.



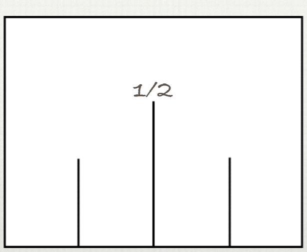
LETS MAKE A REFERENCE INCH

- ☐ FOLD THE PAPER IN HALF AGAIN AND THEN IN HALF AGAIN



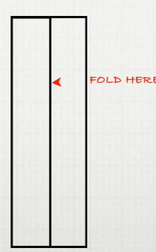
LETS MAKE A REFERENCE INCH

LETS MAKE A REFERENCE INCH

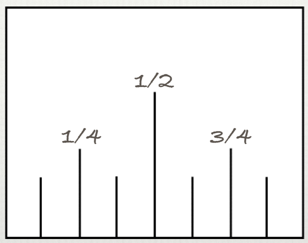


LETS MAKE A REFERENCE INCH

- ☐ FOLD THE PAPER IN HALF AGAIN AND THEN IN HALF AGAIN AND THEN IN HALF AGAIN.

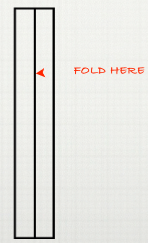


LETS MAKE A REFERENCE INCH



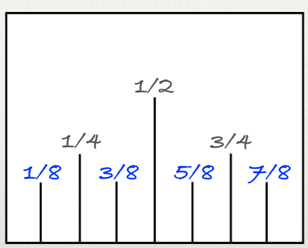
LETS MAKE A REFERENCE INCH

- ☐ FOLD THE PAPER IN HALF AGAIN AND THEN IN HALF AGAIN AND THEN IN HALF AGAIN AND THEN AGAIN.

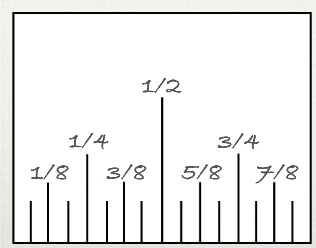


LETS MAKE A REFERENCE INCH

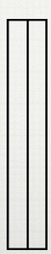
- ☐ OPEN THE PAPER AND MARK THE NEW FOLD LINES WITH THE FRACTIONS 1/8, 3/8, 5/8, AND 7/8.



LETS MAKE A REFERENCE INCH

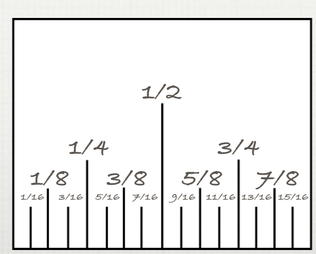


LETS MAKE A REFERENCE INCH

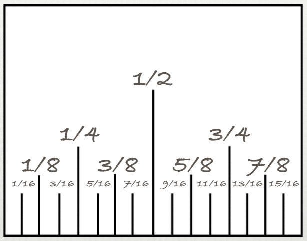


LETS MAKE A REFERENCE INCH

- ☐ OPEN THE PAPER AND MARK THE NEW FOLD LINES WITH THE FRACTIONS 1/16, 3/16, 5/16, 7/16, 9/16, 11/16, 13/16, AND 15/16.

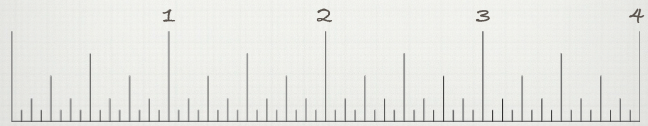


LETS MAKE A REFERENCE INCH



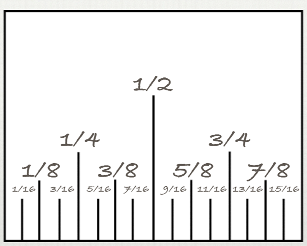
LET'S PRACTICE THE INCH

DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION



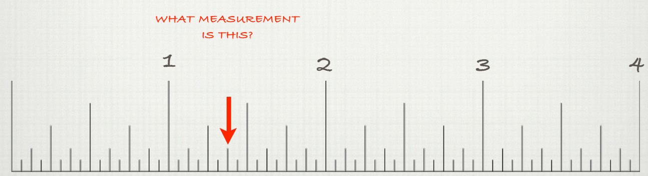
LETS MAKE A REFERENCE INCH

- THIS IS YOUR REFERENCE INCH.
- YOU CAN USE THIS TO DO THE ASSIGNMENT AND TO STUDY FOR THE TEST, BUT YOU CANNOT USE IT ON THE TEST.

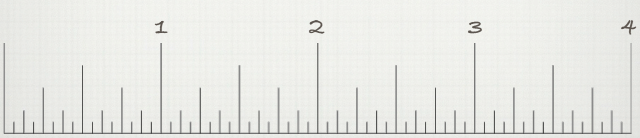


LET'S PRACTICE THE INCH

DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION

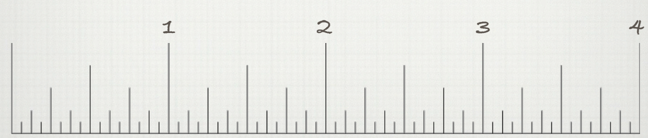


LET'S PRACTICE THE INCH



LET'S PRACTICE THE INCH

DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION



1-3/8"


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
WHAT MEASUREMENT IS THIS?
1 2 3 4


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
1 2 3 4
9/16"


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
1 2 3 4
2-1/4"


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
WHAT MEASUREMENT IS THIS?
1 2 3 4


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
WHAT MEASUREMENT IS THIS?
1 2 3 4


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
1 2 3 4
3-1/2"


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
WHAT MEASUREMENT IS THIS?
1
2
3
4


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
1
2
3
4
1-11/16"

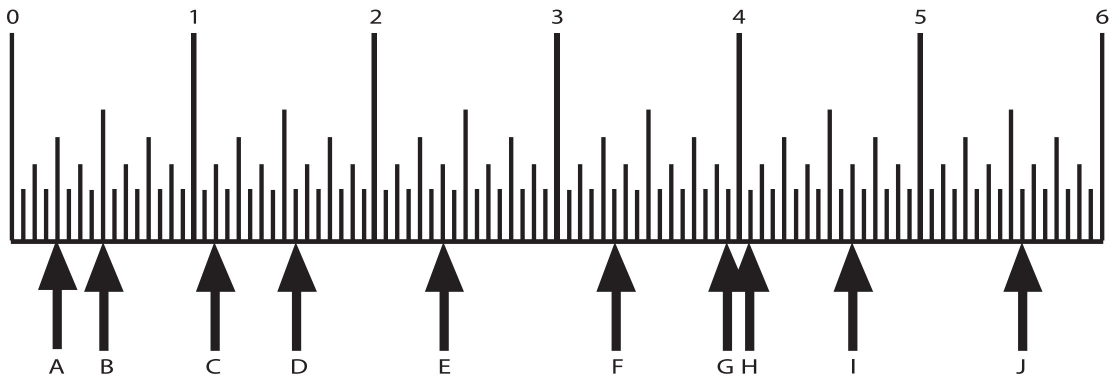

LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
1
2
3
4
3"


LET'S PRACTICE THE INCH
DON'T FORGET TO INCLUDE THE WHOLE NUMBER BEFORE THE FRACTION
WHAT MEASUREMENT IS THIS?
1
2
3
4

Appendix C. Conceptual Understanding Practice Worksheet

CONCEPTUAL UNDERSTANDING PRACTICE WORKSHEET

Directions: In this section, you must write the correct measurement that matches the lettered arrow. Write the correct measurement in the blank next to the corresponding letter.

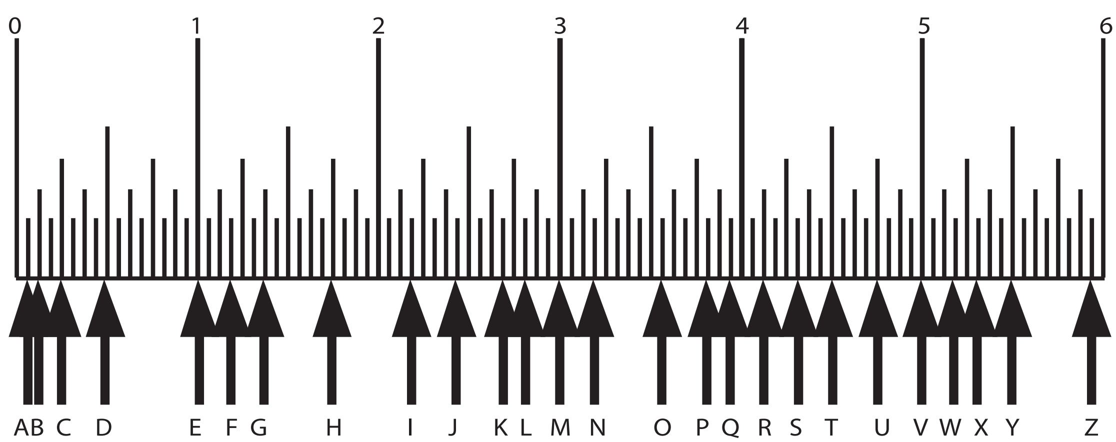


A ________ D ________ G ________

B ________ E ________ H ________ J ________

C ________ F ________ I ________

Directions: In this section, you must write the correct letter in the blank next to the measurement that corresponds with the arrow pointing to that measurement..



1. 4-1/8" ________	6. 3" ________	11. 1/4" ________	16. 4-5/16" ________
2. 1-3/4" ________	7. 3-9/16" ________	12. 1-3/16" ________	17. 5-3/16" ________
3. 2-7/16" ________	8. 4-1/2" ________	13. 5" ________	18. 3-15/16" ________
4. 1/8" ________	9. 5-5/16" ________	14. 1/2" ________	19. 4-3/4" ________
5. 5-15/16" ________	10. 1/16" ________	15. 1-3/8" ________	20. 2-11/16" ________

Appendix D. Memorization Lesson Plan

Terminal Objective: read and identify dimensions on a standard ruler
Performance Objective: Given a diagram of a standard ruler, read dimensions to 1/16th of an inch, using proper or mixed fractions in their lowest terms, with a minimum score of 90% correct.

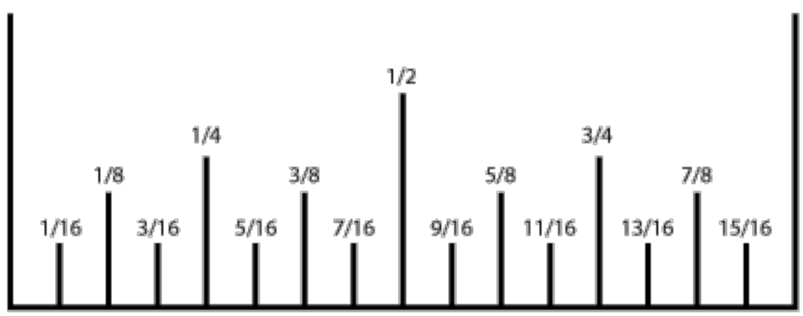
Enabling Objectives:

1. Define the following terms: whole numbers, proper fractions, improper fractions, mixed fractions, numerator, and denominator.
2. Connect correct fractions to their locations on a standard inch.

Laboratory Hardware: None
Learning Activities:

1. Participate in the 5 minute discussion about fractions.
2. Complete the Inch Fraction Memorization worksheet, five times, one at the beginning of five consecutive class periods.

Formative Evaluation: The instructor will walk around the class and make sure students are on task. Each Inch Fraction Memorization worksheet will be assessed to make sure the students are grasping the concept.



Summative Evaluation: Students will be given the posttest at the end of the lesson. This assessment will be used to assess the performance objective for the lesson. The answers for the posttest are as follows:

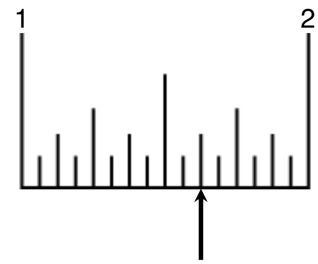
1.	1-5/8”	10.	2-3/8”	19.	20-11/16”	28.	7/8”
2.	3”	11.	45-3/16”	20.	9-5/8”	29.	21-3/8”
3.	4-3/16”	12.	6-1/16”	21.	100-9/16”	30.	35-5/16”
4.	3-9/16”	13.	3-15/16”	22.	½”	31.	5-15/16”
5.	10-1/4”	14.	10-7/16”	23.	77-7/16”	32.	7-1/8”
6.	5-13/16”	15.	9-3/4”	24.	98-13/16”	33.	4”
7.	11”	16.	1-1/8”	25.	2-1/2”	34.	10-1/16”
8.	2-7/8”	17.	2-11/16”	26.	5-3/4”		
9.	8-5/16”	18.	4-1/4”	27.	2”		

Appendix E. Pretest, Posttest, Delayed Posttest

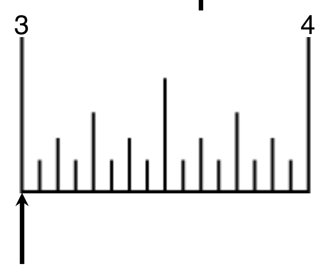
PRETEST, POSTTEST, DELAYED POSTTEST

Directions: Identify the measurements in the following inches by writing the correct fraction or mixed fraction in the blank to the left of each inch.

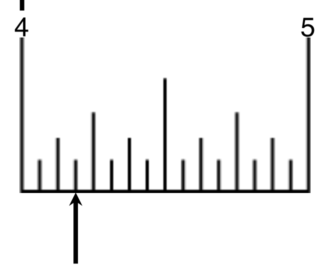
1. ______



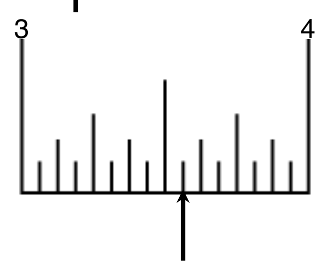
2. ______



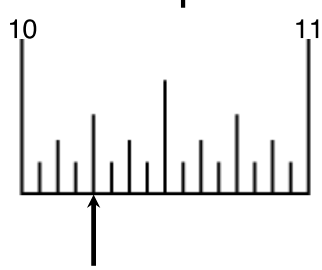
3. ______



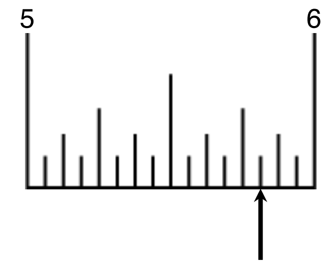
4. ______



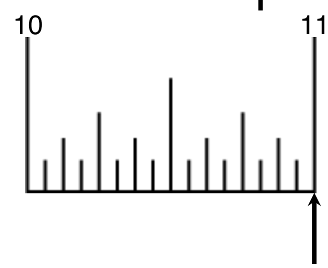
5. ______



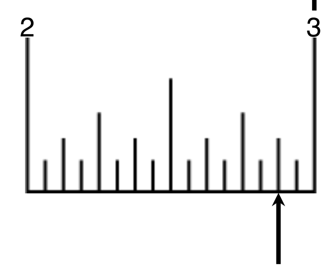
6. ______



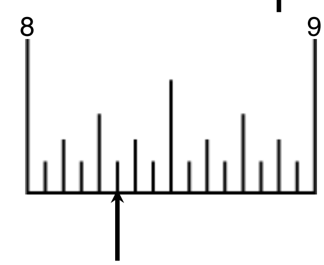
7. ______



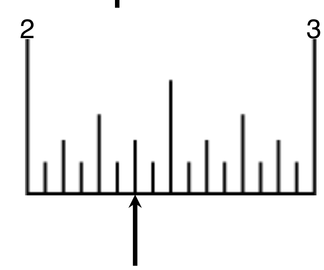
8. ______



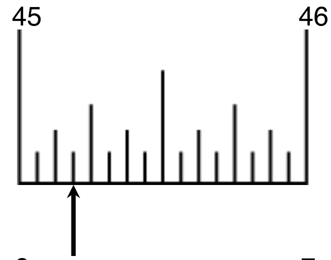
9. ______



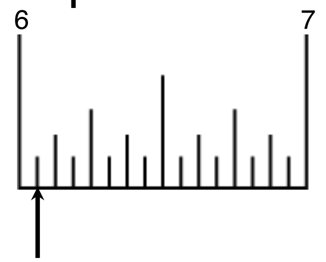
10. ______



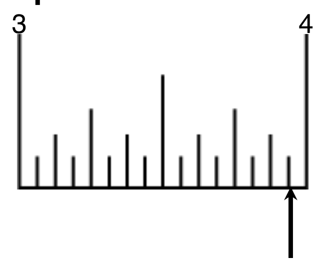
11. ________



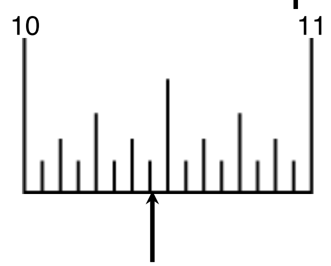
12. ________



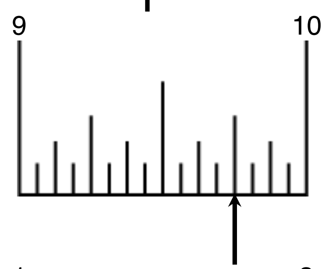
13. ________



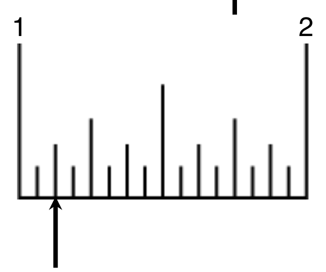
14. ________



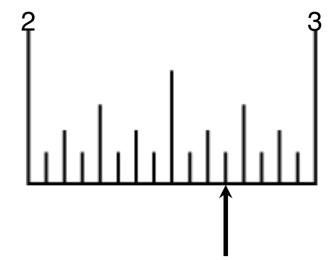
15. ________



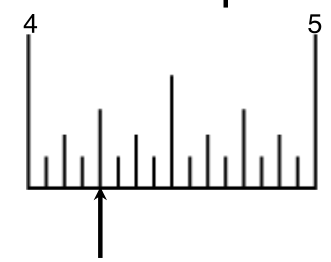
16. ________



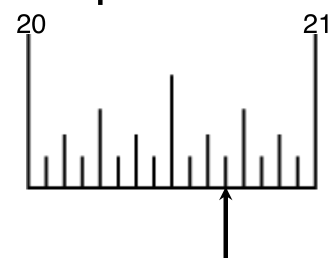
17. ________



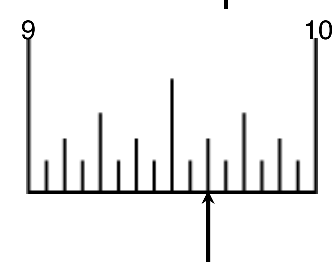
18. ________



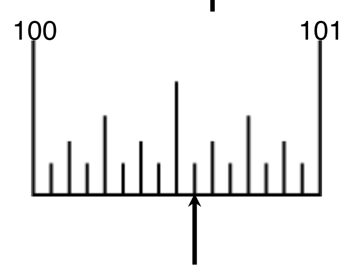
19. ________



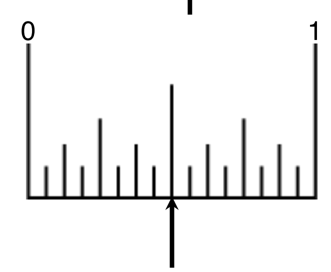
20. ________

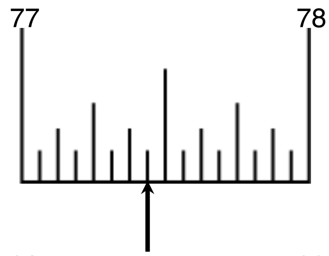


21. ________



22. ________



23. ______


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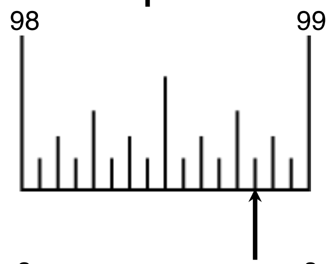
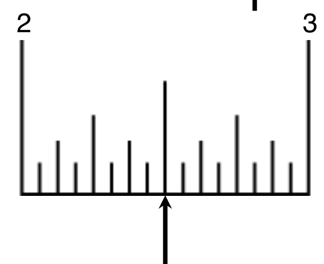
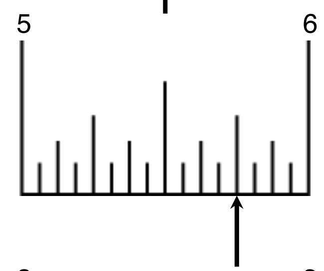
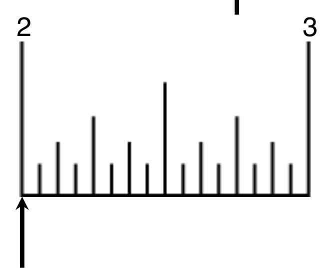
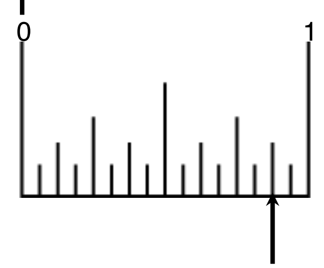
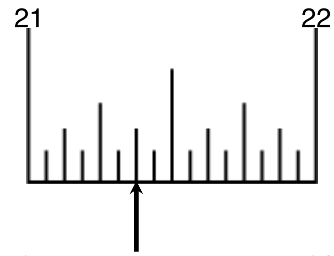


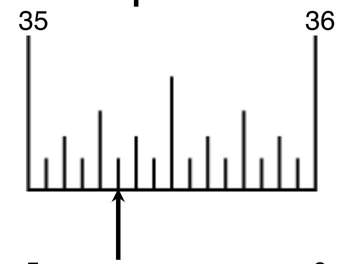
25. ______


26. ______


27. ______


28. ______


29. ______


30. ______


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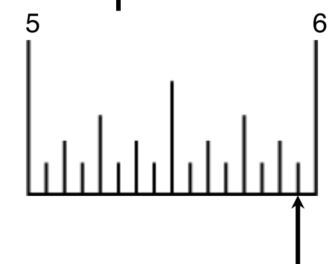
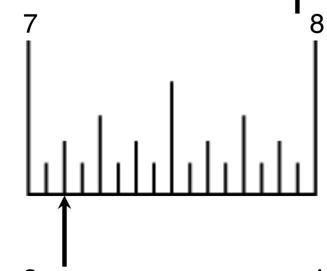


32. ______


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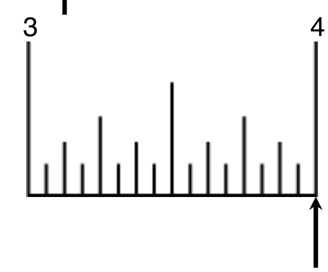

34. ______