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Digital Tools in the Classroom: Measuring the Effectiveness

Jeff Carpenter
Central Connecticut State University

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INTRODUCTION

Measurement is integrated so seamlessly into our daily lives that we barely realize its importance. We use measurement when we take medicine, weigh ourselves, make cookies, tile floor, and compare feats of strength or height or speed in a sporting event. Even though we value measurement skills and teach measurement skills in schools, the results of the 2011 International Mathematics and Science Study (TIMSS) show that U.S. students in both fourth- and eighth-grade are weak in linear measurement skills and understanding as compared to their peers throughout the international community (International Association for the Evaluation of Educational Achievement [IEA], 2013). The National Assessment of Educational Progress (NAEP) findings also bear this out. Eighty percent of fourth grade U.S. students answered incorrectly when asked to determine the length of a toothpick sitting above a ruler (U.S. Department of Education, 2003). In order for students to be capable of using measurements properly in daily life, students' educators need to find better ways to increase students' measuring accuracy.

LITERATURE REVIEW

Research tells us that students' poor performance with measuring skills is directly related to lack of practice. Maral, Oguz-unver and Yurumexoglu found that after students learn about measuring they must participate in many measurement activities to become proficient (2012). Yet, currently, practice through measurement activities is not happening in schools. Students are given few opportunities to practice measuring (Wilson & Blank, 1999). As a result of inadequate practice, students are confused and lack confident (Blitz, Moore, Wright, & Dempsey, 2011).

In school, students typically practice linear measurement by physically measuring common objects and lines on paper with a ruler. For the purpose of this study, this type of practice will be called traditional practice. With the increased availability of computers in the classroom, teachers now have the option of having students practice linear measurement using interactive digital software that “involves the use of game elements, such as incentive systems, to motivate players” (Plass, Homer, and Kinzer 2015 p.259). For the purpose of this study, this type of practice will be called digital practice. The term “authentic measuring task” will be defined as using measurement undertaken for a purpose: to create, build, or test.

The purpose of the study is to determine if, compared to traditional practice, digital practice increases student measuring accuracy on an authentic task. Therefore the study explores the relative efficacy of digital versus traditional practice for increasing student measurement skills in applied situations. The researcher is a teacher of project-based middle school technology education courses. The school is a sixth- through eighth-grade suburban school with approximately 450 students. Students are randomly assigned from the entire student body. Each student takes a double period of technology education every other day for one quarter of each school year. If digital practice is an effective alternative this could have a significant impact in a technology education classroom, as well as other disciplines.

Digital practice differs from traditional practice in significant ways. Digital practice is likely learners with more practice examples than traditional practice. Traditional practice is limited to objects the teacher measured prior to the practice whereas digital practice systems are computer generated and, therefore, abundant. Digital practice allows each student to work at the individual’s own level because the computer will repeat the same concept with different examples for students who need more practice or the computer will generate more difficult examples for students who catch on quickly. Traditional practice, on the other hand, most often offers students practice using the examples the teacher has set-up in advance without on-going modification based on progress. Digital practice also has the advantage of providing students with immediate feedback whereas in traditional practice students generally have to wait until they measure a few items to receive feedback when the instructor becomes available. Research suggests that students value immediate feedback they can use immediately to improve performance (Marie, 2016).

Notwithstanding the above recommendation regarding digital practice as a means to increase students’ measuring skills, traditional practice seems to have one big advantage over digital practice. During traditional practice students practice the skill in the same way it is applied to an authentic task, physically using a ruler and objects. This raises a key research question: Can students who participated in digital practice transfer the skill to physically completing an authentic task? Research suggests they can. The research shows show that the human brain is able to accommodate switching among different mediums: pen and paper, keyboarding, and mobile devices. This is referred to as 'plasticity' (Cavanaugh, Giapponi and Golden, 2016). In conducting this study, I hypothesized that students 'plasticity' should allow them to participate in digital practice and then use the skills they have practiced to complete an authentic task, accurately.

METHODS

Group comparative research design was used to investigate cause-and-effect relationships between two groups. This design was chosen for two reasons. First, this design does not interrupt regular classroom routine and curriculum. Second, there is existing data in the form of student project work to use as a comparison group from past students who practice measurement traditionally. The two groups being compared are both composed of sixth grade students randomly assigned to sections of the same technology education classes in a Connecticut suburban middle school with a population of approximately 450 students. Group one students had previously engaged in technology education the previous quarter. Group one was composed of 35 students assigned to two sections of technology education. In section one of group one, there were ten boys and seven girls: Three of the students received special education services. In section two of group one, there were nine boys and nine girls: Three students received special education services. Group two was composed of 35 students assigned to two sections of technology education. In section one there were eight boys and eight girls: Two students received special education services. In section two there were eight boys and eleven girls: Two students received special education services. Students in both sections of both groups were taught by the same teacher, and were exposed to the same measurement mini-lessons: All students in both groups completed the same air racer project. The difference between the two groups was the way measurement was practiced. Group 1 practiced measurement traditionally and group two practiced measurement digitally. The research question is as follows: What is the difference in students' measuring accuracy on the air race project when using traditional methods to practice measurement as compared to students who practiced measuring digitally?

Two methods were used to collect data: a survey to gauge students' attitude, and an air racer project which provided the context to compare students' measuring accuracy, in situ. The digital practice group took a Likert-type survey on measurement before and after the project to gauge students' attitudes towards measurement. The Likert-type survey was taken anonymously online, using school computers. This delivery method was designed to allow students to give honest opinions without any worry of identification. The survey contained eleven questions with a five-point scale: five questions were included to determine the participants' perceptions regarding the value of measurement; four questions were included to find how confident the participants felt using measurement and two questions were included to determine the participants' perception of their need for measurement skills.

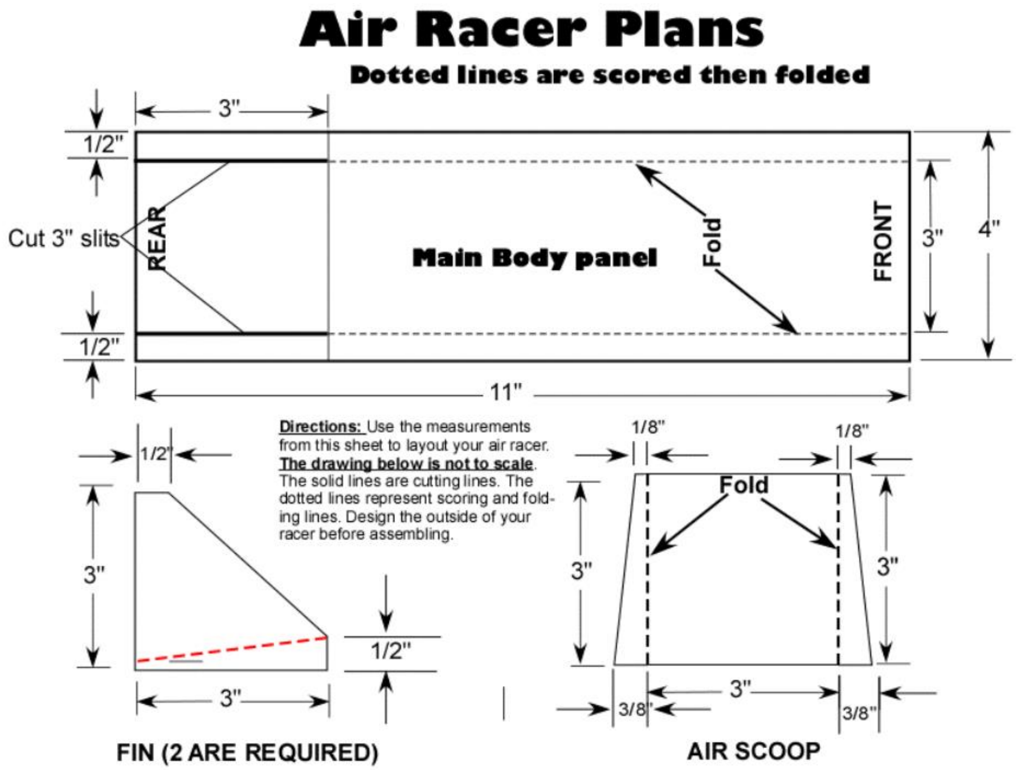

Figure 1. Air racer plans used by students as a blueprint for the project.

Data on measurement accuracy was collected from both groups using the air racer project. An air racer is a floor skimming vehicle launched by slingshot. Each air racer is built from several student-made parts, hand drafted onto heavy card stock using dimensions from a scaled blueprint. Precise placement and sizing of all features during hand drafting is necessary to ensure the reliability and performance of the vehicle. Data regarding each student's success (aka measurement skills) was collected on the practice method, section, and accuracy regarding the placement and length of each line on the air racer at three different incremental levels, measuring with a 1 inch, ½ inch, and 1/8 inch increments as seen in Figure 1. I chose this method of data collect to leverage measurable student performance so as to gauge students' ability to use a ruler accurately in an authentic task without concerns that the study might interfere with the normal educational process. The data were collected at three incremental levels to determine if students' performances differed when students were required to use different ruler increments to obtain accurate measurements.

Both sections of group one participated in traditional practice because that is the way measurement has always been practiced. Copies of their air racer patterns were made at the time as a back-up in case the students made an error while elaborating work on the original. It is these left-over back-up copies that were used to collect data. Both sections of group two practiced measuring digitally. Copies of their air racer patterns were again made as a back-up. It is these back-up copies that were used to collect data. Thus the study measures initial performances on the task for members of both control group participants and study group participants.

On day one of each course undertaken by members of Group two, students in both sections of both groups took the Likert-type attitude survey, participated in mini-lessons on measurement and participated in digital measuring practice for 20 minutes. At the beginning of the next three classes students participated in digital measuring practice for ten minutes each day. During the next two classes, students in group two drew the air racer project patterns and then took the post attitude survey.

I analyzed the data I collected to get a general picture of the class as a whole. For student attitude the mean on each item on the Likert-type survey was compared on the pre- and post-survey. Using independent-measures t test, I calculated a mean for the students' accuracy using each measuring increment, 1 inch, ½ inch, and 1/8 inch. I compared the mean for each increment for the students who participated in traditional practice with the mean on those same increments for students who participated in digital practice.

I assert that this study has the potential to yield reliable findings because there is no ambiguity in measuring: In the context of the air racer exercise, the length of a line is right or wrong. Moreover, on this project, students had multiple opportunities to measure using each increment of length.

DATA ANALYSIS

Data was collected from each participant on the individual's accuracy measuring eight lines using the one-inch ruler interval, six lines using the half-inch ruler interval, and four lines using the 1/8" ruler interval. As shown in Table 1, below, students who participated in traditional practice measured accurately 239 out of 280 lines or 85.36% using the one-inch ruler interval compared to 233 out of 280 lines or 83.21% one-inch interval lines measured accurately by students who participated in digital practice. A t-value of 0.57357 and p-value of 0.575358 shows the difference between the two groups is not statistically significant.

Students who participated in traditional practice measured accurately 167 out of 210 lines or 79.52% using the half-inch ruler interval compared to 170 out of 210 lines or 80.95% half-inch interval lines measured accurately by students who participated in digital practice. A t-value of - 0.35908 and p-value of 0.727 shows the difference between the two groups is once again not statistically significant.

Finally, students who participated in traditional practice measured accurately 93 out of 140 lines or 66.43% using the eighth-inch ruler interval compared to 97 out of 140 lines or 69.29% eighth-inch interval lines measured accurately by students who participated in digital practice. A t-value of - 0.63779 and p-value of 0.547162 shows the difference between the two groups is once again not statistically significant.

As noted above, members of the digital practice group took the Likert-type survey on measurement before and after engaging in the air racer project to gauge participants' attitude towards measurement. The survey contained eleven questions with a five-point scale: five questions were used to determine the participants' perceptions regarding the value of measurement, four questions were used to determine how confident the participants were in measurement and two questions were used to determine the participants' perception of their need for measurement skills. A mean was calculated for each pre- and post- project question, and the t-value and p-value were calculated for each question to determine significant. (See Table 3, below, for details.) The p-value for every question was greater than 0.123 thereby indicating there was no statistical significance in the difference between group members' responses from the pre-project survey questions and the post-project survey questions. Even though there is no statistical significance, data collect from question number five of the survey suggests the possibility that students' confidence measuring small fractions increased over the course of the study. (See Figure 3, below, for details).

Table 1.

Line accuracy data from traditional practice methods.

Ruler interval	Line number	Correct	Incorrect	Total Lines	Total % Correct	Interval Mean
1”	1	30	5	280	85.36%	29.88
	2	32	3			
	3	27	8			
	4	29	6			
	5	33	2			
	6	31	4			
	7	28	7			
	8	29	6			
½”	9	24	11	210	79.52%	27.83
	10	26	9			
	11	29	6			
	12	30	5			
	13	31	4			
	14	27	8			
1/8”	15	25	10	140	66.43%	23.25
	16	24	11			
	17	23	12			
	18	21	14			

Notes. Thirty-five student projects measured per line.

Table 2.

Line accuracy data from digital practice methods.

Ruler interval	Line number	Correct	Incorrect	Total Lines	Total % Correct	Interval Mean
1”	1	33	2	280	83.21%	29.13
	2	28	7			
	3	31	4			
	4	23	12			
	5	31	4			
	6	27	8			
	7	30	5			
	8	30	5			
½”	9	25	10	210	80.95%	28.33
	10	31	4			
	11	28	7			
	12	27	8			
	13	29	6			
	14	30	5			
1/8”	15	28	**7**	140	69.29%	24.25
	16	22	13			
	17	24	11			
	18	23	12			

Notes. Thirty-five student projects measured per line. Difference from digital not statistically significant.

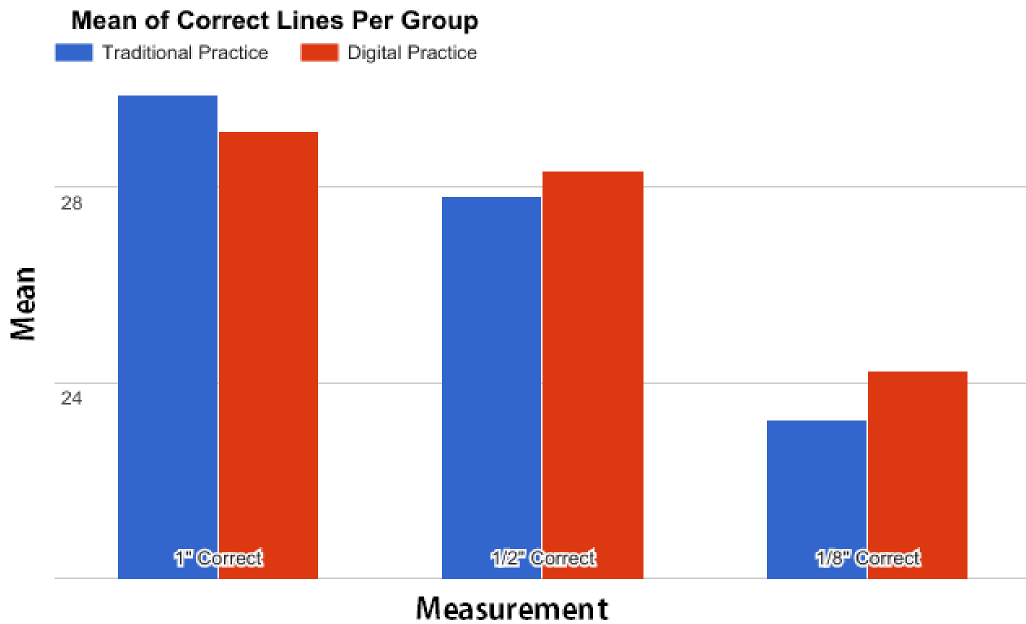

Figure 2. Mean of correct lines made by students comparing members of groups using traditional and digital practice methods.

Table 3.

Data for student attitude towards measurement before and after project.

Question Number	Question Category	Pre-Mean (SD)	Post-Mean (SD)	t-value	p-value	SS
1	value	4.09 (0.56)	4.09 (0.82)	-0.047	0.962	
2	value	3.71 (0.95)	3.50 (1.16)	0.826	0.412	
3	value	2.63 (1.23)	2.61 (1.30)	0.050	0.960	
4	value	4.00 (1.08)	3.97 (0.93)	0.126	0.900	
5	value	3.80 (1.05)	3.78 (0.97)	0.075	0.940	not significant
6	confidence	4.46 (0.70)	4.50 (0.84)	-0.227	0.821	
7	confidence	3.89 (0.71)	3.84 (0.80)	0.225	0.823	
8	confidence	2.09 (0.98)	2.25 (1.08)	-0.653	0.516	
9	confidence	3.80 (0.83)	4.13 (0.87)	-1.56	0.123	
10	need	2.89 (0.96)	2.88 (0.97)	0.045	0.964	
11	need	3.65 (0.98)	3.78 (0.91)	-0.576	0.567	

Notes. not significant $p < .05$.

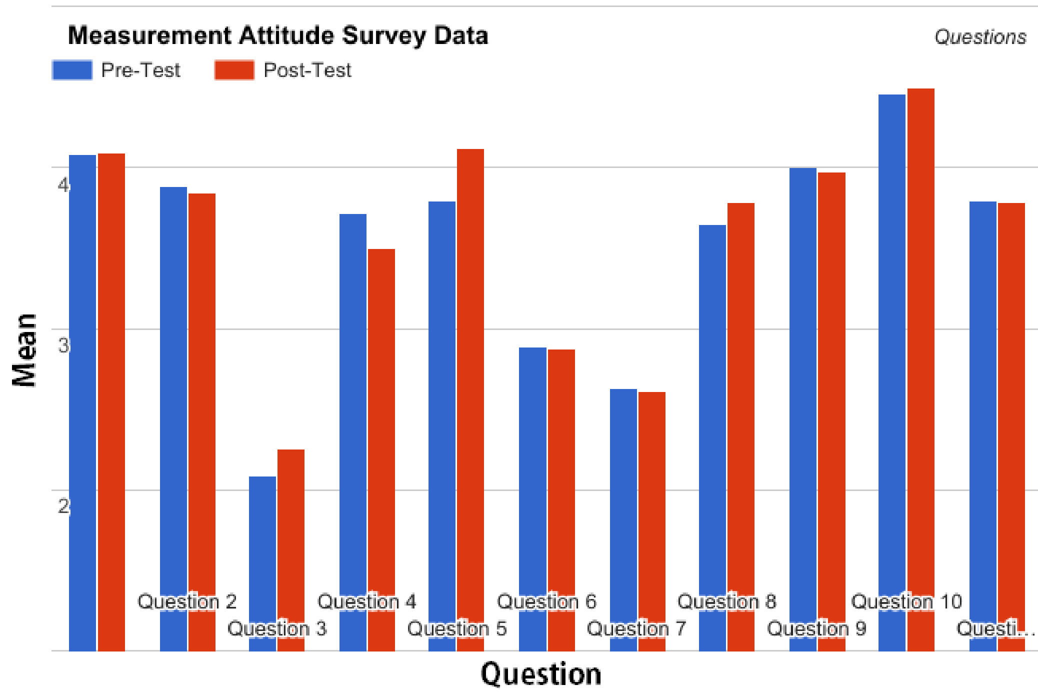

Figure 3. Shows the mean of each question on the attitude survey. A higher mean indicates a higher level of confidence, greater value perceived, or a more positive attitude.

CONCLUSION

Today technology is supplanting or supplementing many traditional teaching methods. Questions regarding the effectiveness and best practices for effective use of these technologies should be foremost in minds of educators designing new curricula. Toward this end, I attempted in this study to determine if digital measurement practice is better than traditional practice methods as practice techniques for measuring with a ruler. The data gathered during the air racer project showed there to be no difference between the measuring accuracy of students who practiced measuring traditionally compared to students who practiced measuring digitally. Moreover, survey data regarding the attitudes of the students who engaged in digital practice during the air racer project indicated these students' attitudes toward measurement did not change in any statistically significant way from the beginning to the end of the exercise. A suggestion for a future study would be to increase the population size of the experiment and control groups. It would also be of potential value to attempt to pre- and post-exercise attitudes of members of the control group undertaking traditional measurement practice regimes to determine if statistically significant attitude changes occur among members of the control group.

Since this study suggests that student outcomes from digital practice is at least comparable to the outcomes of students who engage in traditional practice, teachers may wish to consider other potential benefits of digital practice when selecting a practice method for their students. For instance, the digital tools require zero setup. Students can open a browser, practice, and just close the browser. Therefore, teachers can offer students practice on the fly if a lesson runs short or if individual students finish their work early. In addition, absent students can practice at home. Since research tells us that achievement is linked to application and repeated practice, the ability to have students practice measuring skills at a moment's notice potentially could lead to students getting more practice despite the constraints of the overfilled school day.

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Student Attitude Survey Questions

Question 1	I see value in the ability to accurately measure objects.
Question 2	Having good measurement skills for my future outside of school is
Question 3	The future career you're interested at the moment, do you think that career uses measurement skills?
Question 4	Having good measurement skills in high school and/or college is
Question 5	Having good measurement skills in middle school is
Question 6	I'm confident my ability to measure large fractions like whole inches or halves of an inch.
Question 7	In general, I have good feelings towards making measurements.
Question 8	Using a ruler to make measurements makes me nervous
Question 9	I'm confident in my ability to measure small fractions like quarters of an inch or eighths of an inch.
Question 10	I use my measurement skills to make measurements on my own
Question 11	I have had classroom opportunities to practice my measurement skills