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Changing Preservice Elementary Teachers' Perceptions of Teaching and Learning the Metric System

Fuchang Liu
Mara Alagic
Wichita State University, U.S.A.

Forty-eight American preservice elementary teachers took the Metric System Questionnaire as pre- and posttest, designed to assess their perceptions and knowledge about teaching, learning, using and converting to the metric system. As intervention, they were interviewed, reflected on the metric system, and used metric measurements on all occasions. It was found that participants' perceptions of the metric system significantly improved after the intervention. Such improvement is the most outstanding for the construct of the metric system being important in children's learning of mathematics. This study also found that initially participants significantly underestimated metric measurements of familiar objects. It is concluded that it is very important for teachers, school administrators, and policymakers to realize the academic benefits the metric system has for America's future generations.

Key words: customary system, metric system, metric system questionnaire, perceptions, American preservice elementary teachers

The United States is one of only three countries in the world that still use the customary system of measurements (the foot-pound-gallon system). Formal efforts to convert to the metric system (the meter-gram-liter system) in the U.S. date back to the middle of the 19th century when U.S. Congress passed the Metric Act of 1866, legally recognizing the metric system of measurement in the United States. The U.S. became an "officially metric nation" in 1893, the year the Secretary of Treasury declared a set of metric standards as the country's "fundamental standards of length and mass" (Hebra, 2003). Now, over a century later, while the metric system is used in some professions such as medicine and engineering and exclusively in high school science classes (Phelps, 1996), the customary system is still widely used in American people's daily lives.

Numerous attempts have been made to convert to the metric system in the U.S. and, obviously, most of them have been unsuccessful (e.g., Henshaw, 2006; Whitelaw, 2007). As a recent example of the nation's failed attempt for metric conversion, the Omnibus Trade and Competitiveness Act of 1988 designated the metric system as the preferred system of measurements for U.S. trade and commerce. Responding to the act, the Federal Highway Administration developed a metric conversion plan and timetable, which included the conversion to metric units of highway signs by September, 1996 (General Accounting Office, 1995). Today, an overwhelming majority of the nation's highway signs are still in miles, feet, and inches.

For students to function properly in society, American educators teach both systems, and elementary school mathematics textbooks generally give equal weight to the two systems. As a reflection of this dual requirement, National Council of Teachers of Mathematics (2000, p. 172) stated that in grades 3 – 5, "more emphasis should be placed on the standard units that are used to communicate in the United States (the customary system) and around the world (the metric system)." Furthermore, despite its claim that it "supports the efforts by the U.S. government to make a transition to the metric system as the nation's primary measurement system," National Council of Teachers of Mathematics (2006) unequivocally stated that "schools should provide students with rich experiences in working with both the metric and the customary systems of measurement while developing their ability to solve problems in either system".

Phelps (1996) made a convincing argument that 71 school days could be saved by teaching metric only, plus another 11 days saved by dropping instruction in fractions tied to the customary measurement, during a student's schooling years. Translated into dollar amount, that was a huge annual saving of about $18 billion. According to the calculations in Phelps' study, for nine common attributes (length, weight, capacity, etc.), an American student would have to memorize 117 names and conversion ratios for complete fluency with the customary system whereas that number is only 17 for the metric system. It was thus assumed that the metric system could be learned to an equivalent level of mastery in 15% of the time it would otherwise take to learn the customary system.

However, the fact that the metric system is easier to teach, learn, and use (this fact is widely accepted in today's elementary mathematics textbooks used in the United States. See McGraw-Hill, 2007) and that converting to it makes much financial sense is only part of the story. More importantly, not using the metric system is considered by many to be one of several factors that contribute to the sharp disadvantage in the early development of mathematical concepts and skills in American children as compared with Asian children (Berk, 2003). Comparative studies have shown that American children were consistently outperformed by Asian children with regards to abstract counting, understanding of base-ten concepts and place value, and understanding of multidigit addition and subtraction (Fuson & Kwon, 1992; Miller, Smith, Zhu, & Zhang, 1995; Miura, Okamoto, Kim, Steere, & Fayol, 1993). Among other cultural factors, the metric system, with its ones, tens, hundreds, and thousands values in all areas of measurement, is universally used in the studied Asian countries but not in the United States. As observed in Delgado (2013), the more transparent metric system better supports conceptual thinking about scale and measurement than the idiosyncratic customary system and it mediates learners' understanding of scale and measurement much as number words mediate counting and problem solving. This led some authors to believe that the metric system's unavailability to American children hindered or delayed their learning of those important mathematical concepts (Fuson & Kwon, 1992; Han & Ginsburg, 2001; Miura, Okamoto, Vlahovic-Stetic, Kim, & Han, 1999).

Nevertheless, the important role the metric system plays in children's learning of mathematics has not been adequately recognized by American educators and policymakers. And disappointingly, to the best of our knowledge, there is a paucity of studies in this regard, perhaps due to the very fact that the U.S. is the only industrialized country that still uses the customary system. Another difficulty is that few groups use a system that is exclusively in a base other than 10 (Dowker, 2005), but rather a mixture of both base-10 and nonbase-10 systems.

With so little research attention given to the role the metric system plays in academic fields, researchers practically know nothing about issues on teaching and learning the metric system and who is responsible for promoting its use. Conclusions drawn from such studies may have potentials to not only inform American policymakers of how best to convert to the metric system, but also inform schoolteachers of how best to teach the metric system, as they are the very people who will ultimately shoulder the responsibility of teaching the future generations how to use it (Monroe & Nelson, 2000). Hence the rationale for the present study.

This study was driven by the following research questions:

1. Will engaging American preservice elementary teachers in reflecting on and actually using metric measurements improve their perceptions of teaching and learning the metric system?
2. Who do American preservice elementary teachers feel should play a greater role in promoting schoolchildren's learning and using the metric system?
3. What is American preservice elementary teachers' general knowledge about the metric system?

Method

Participants

Two classes of preservice elementary teachers taking a required course "Mathematical Investigations" at a mid-western U.S. university were recruited for participation in this study. The first class met for 2 hr and 10 min on every weekday for three consecutive weeks during the summer. The second class met for the same length of time but once a week for 15 weeks during the fall semester. The total number of participants was 48. All of them were juniors, with the majority being female, Caucasian, and in their early 20s (mean age = 24.8 ±6.0 years. See Table 1).

Table 1
Participants' Demographic Data

Category (N = 48)	*f*	%
Age Group		
20	7	14.6
21-25	29	60.4
26-30	5	10.4
31-35	2	4.2
36-43	5	10.4
Gender		
Female	47	97.9
Male	1	2.1
Ethnicity		
Caucasian	43	89.6
Other	5	10.4

Intervention

The intervention involved three components: interview, reflection, and mandatory use of metric measurements in all assignments and on other occasions as well.

Interview. Participants were divided into groups of about 8 to 10 people, and one of the authors of this article conducted a semi-structured interview on each group. All interview sessions were finished during the first one third of class meetings. Seven questions were posed (see Appendix A) and the responses were audiotaped.

Reflection. A discussion board was created on Blackboard, an online academic system that all faculty and students had access to, as a platform for participants to reflect and share their reflections. Participants were divided into groups of four or five and were asked to post at least two entries each week. In the first entry they generated their own ideas on the topic suggested and, in subsequent entries, reflected on previous ones posted by their peers within the group. On a rotating basis, one member from each group would summarize all the entries generated. Then the summaries would be brought to class for face-to-face sharing. The topic for reflection read, "Browse through the following resources and share with others what you might want to incorporate in your future mathematics and/or science classroom pertaining to the metric system." Three internet addresses, of the National Council of Teachers of Mathematics, National Science Teachers Association, and the US Metric Association, were listed.

The interview and reflection served a dual purpose. First, they were intended to make participants aware of the intrinsic merits of the metric system, the benefits of using it, and the advantages of converting to it. Reflecting on and talking about all these aspects with regards to teaching, learning, using and converting to the metric system may help dispel misunderstandings and stereotypes about this system. This is very much like the healing effect of disclosure (Pennebaker, 1995, 1997). Second, the interview and reflection would likely generate rich data, which may ultimately help researchers gain a better understanding of how to help future teachers teach and students learn the metric system in the most efficient manner (to save space, though, such data are not presented in this article but will be reported elsewhere).

Use of metric measurements. Participants were required to use metric measurements where at all possible. This included class discussions and written assignments. Unavoidable use of the customary system, such as the distance between campus and a nearly city in miles, was allowed but discouraged.

Instrument

As there was no instrument available in existing literature, we developed a "Metric System Questionnaire" for measuring perceptions of teaching, learning, using and converting to the metric system. First, we informally interviewed several prospective participants about what they knew and what their beliefs and concerns were about the learning, teaching, and using the metric system. Second, one of the authors of this article had participants from another study discuss several aspects of these issues (Liu, 2008). Opinions generated from that study were referenced.

The "Metric System Questionnaire" was composed of three parts. Part 1 consisted of 14 Likert-type "pro-metric" questions, followed by five choices ranging from 5 to 1, with higher scores indicating better perceptions of or more favorable attitudes towards the metric system. These questions were further composed of four constructs: knowledgeable about the metric system, perceiving the metric system as better than the customary system, importance of the metric system in children's learning of mathematics, and importance of promoting the metric system (see Appendix B).

Part 2 was a continuation of the last two questions from the first part: "Students' *learning* of the metric system should be promoted" and "Students' *use* of the metric system should be promoted." Those that chose either "Agree" or "Strongly Agree" were asked to check the persons/entities that they believed should be playing a major role in promoting the learning or using of the metric system. Seven choices were provided: teachers, schools, school districts, parents, state government, federal government, and local corporations. Participants were also asked to check which system should be taught at schools.

Part 3 was two "estimate in metric and then explain" problems. One of them read, "Without asking anybody or looking at a ruler about how long a centimeter is, what is your best estimate of the length of a new, regular pencil in centimeters? Briefly explain how you got this answer." The other problem, similarly worded, was about the volume of a regular, fully inflated basketball, in liters.

Cronbach's *alpha* was conducted on both the pre- and posttest scores of the Likert-type questions. The coefficient *alpha* index of 0.89 for pretest items and that of 0.84 for posttest items indicated a high estimated internal reliability.

Procedure

The Metric System Questionnaire was administered to each class during their first day of class as pretest. Intervention occurred throughout the semester. One of the authors taught both classes, following the same curricular guidelines and covering the same curricular content. On the last day of class, the Metric System Questionnaire was given as posttest.

Results

Results concerning the responses to the Metric System Questionnaire are reported as follows. Data generated in participants' interviews and reflections will be reported elsewhere.

To address research question 1 concerning whether engaging American preservice elementary teachers in interviewing on, reflecting on and actually using metric measurements would improve their perceptions of teaching and learning the metric system, participants' responses to all the 14 pro-metric questions were first converted to a mean score. A paired samples t-test was conducted to compare the mean posttest score (M = 3.88) against its pretest counterpart (M = 3.59). This was found to be statistically significant, t (47) = 3.12, $p < .01$, $\eta^2 = .17$, indicating that American preservice elementary teachers' perceptions of and attitudes towards the metric system will improve after being interviewed on the teaching and learning of the metric system, reflecting on incorporating the metric system in their future teaching, and using metric measurements on all occasions.

To determine if there were any changes regarding the different aspects of the general perceptions of and beliefs about the metric system, each participant's pre- and posttest responses on the four constructs were subjected to paired samples *t*-tests, with a Bonferroni adjustment performed and the alpha level established at .013 (.05 ÷ 4). It was found that the construct of the metric system being important in children's learning of mathematics caused statistically significant improvement on participants' posttest scores, suggesting that after the intervention, American preservice elementary teachers will have a better perception of the metric system in its importance in children's learning of mathematics. The other constructs did not survive the Bonferroni adjustment.

Table 2

Pre- and Posttest Means, Standard Deviations, and T-test Results of Perceptions of the Metric System by Construct (N = 48)

Construct	Pretest *M (SD)*	Posttest *M (SD)*	*t*	*p*	η^2
Knowledgeable	2.98 (0.99)	3.26 (0.96)	2.06	.045	.08
Metric better	3.19 (0.73)	3.42 (0.72)	1.81	.077	.07
Important in math	3.77 (0.74)	4.22 (0.69)	3.46	.001**	.20
Promoting metric	4.05 (0.73)	4.30 (0.53)	2.19	.033	.09

** $p < .013$.

To address research question 2 regarding who American preservice elementary teachers feel should play a greater role in promoting schoolchildren's learning and using of the metric system, responses to the three corresponding questions were examined. Results reported in Table 3 reveal that participants most likely regarded teachers, schools, school districts, and parents as responsible for promoting the learning and using of the metric system. This is true for both pre- and posttest data. However, there was a significant increase in the last three items checked: state and federal governments and local corporations from pre- to posttest (from an average of 16.7% to 37.5% for promoting learning and from an average of 18.1% to 33.3% for promoting using the metric system).

To address research question 3 regarding the status of American preservice elementary teachers' general knowledge about the metric system, two "Estimate in metric and explain" problems were devised. The results are reported below.

1. The pencil problem. The actual length of a new pencil is about 19 cm. The maximum estimate was 100 cm and the minimum was 3.5 cm. Four estimates at pretest exceeding the mean by 2.5 standard deviations were removed (no estimate at posttest exceeded this threshold). The estimates at pre- and posttests were each subjected to a one-sample *t*-test against the test

value 19. It was found that participants significantly underestimated the problem on both occasions (see Table 3). Moreover, a paired samples *t*-test did not reveal any significant change between the pre- and posttest mean estimates. This suggests that American preservice elementary teachers' general knowledge of metric measurements remained relatively stable and did not improve with the intervention.

Table 3

Frequencies and Percentages of "Who Should Promote Learning the Metric System" and "Who Should Promote Using the Metric System"

(N = 48)

Persons/Entities	Promote learning metric		Promote using metric	
	Pretest	Posttest	Pretest	Posttest
	f (%)	f (%)	f (%)	f (%)
Teachers	30 (62.5)	37 (77.1)	27 (56.3)	33 (68.8)
Schools	28 (58.3)	36 (75.0)	25 (52.1)	33 (68.8)
Schools district	26 (54.2)	35 (72.9)	21 (43.8)	27 (56.3)
Parents	21 (43.8)	27 (56.3)	19 (39.6)	26 (54.2)
State government	13 (27.1)	21 (43.8)	13 (27.1)	16 (33.3)
Federal government	9 (18.8)	23 (47.9)	10 (20.8)	17 (35.4)
Local corporations	2 (4.2)	10 (20.8)	3 (6.3)	15 (31.3)

The strategies participants used to obtain an estimate were coded into 11 categories. Since estimates at posttest were not significantly different from those at pretest and that half of the participants reported using the same strategies on both occasions, they were analyzed together. Table 7 shows the strategies used, with the frequency, percentage, and the mean estimate by each strategy.

It is interesting to note that resorting to customary measures and then converting to centimeters (strategy 11) produced the closest estimates (M = 18.9 cm). This is probably because most participants had frequent exposures to customary measures and would not be too far off in picturing how long a pencil was in inches. If they knew the correct conversion ratio (most of them mentioned 1 inch being equivalent to 2.5 or 2.54 cm), they could get a very close estimate. In contrast, estimates using a common object with a supposedly "known" metric measure (strategy 9) were among the worst. Most participants who chose their fingers as a metric reference thought that they were about 1 cm wide. When they imagined the number of index fingers taking up the length a pencil based on this erroneous ratio (most adults' index fingers are much wider than 1 cm), the end results could be considerably off.

It is worth mentioning that even though the average estimate at posttest did not significantly differ from that at pretest, it inched closer to the actual length. Also, there were no extreme scores at posttest. This at the very least indicates that the few participants who produced extreme scores at pretest (such as 100 cm) managed to get their estimates to the normal range.

2. The basketball problem. The volume for a regular basketball (for adult players' use) is about 7.1 liters. The maximum estimate produced was 30 liters and the minimum was 1 liter. After removal of two estimates exceeding the mean by 2.5 standard deviations, pre- and posttest data were subjected to a paired samples *t*-test, which did not reveal any significant change (see Table 4).

Table 4

Means, Standard Deviations, and T-test Results for Estimates of Length of Pencil and Volume of Basketball

Test	M	SD	t	p
Pencil (Test Value: 19)				
Pretest (n = 42)	15.1	5.0	–5.1	.000
Posttest (n = 47)	15.6	4.8	–4.9	.000
Basketball (Test Value: 7.1)				
Pretest (n = 39)	3.7	2.3	–9.6	.000
Posttest (n = 44)	4.4	2.8	–6.4	.000

Table 5

Frequency, Percentage, and Mean Estimate by Each Strategy Used in Estimating Length of Pencil

Strategy (n = 89)	f	%	M (cm)
1. "I don't know"; Or left blank	2	2.2	-
2. "I guessed"	14	15.7	13.2
3. "I estimated" or "I pictured it in my head"	7	7.9	16.3
4. Used a wrong conversion ratio (e.g., 1 in. = 10 cm)	2	2.2	-
5. "Centimeters are smaller than inches"	4	4.5	13.0
6. Used a common object (e.g., finger) as a guide	11	12.4	15.0
7. "I converted from inches to centimeters" (ratio not specified)	3	3.4	-
8. Used a common object with a known customary measure (e.g., "My hand width is about 4 inches") and then converted	1	1.1	-
9. Used a common object with a known metric measure (e.g., "My index finger is about 1 centimeter wide")	18	20.7	13.8
10. "I imagined the length of a centimeter going into a pencil"	2	2.2	-
11. Used a conversion ratio without an object as reference (e.g., "An inch is 2.54 centimeters")	23	25.8	18.9

Note. Mean estimates with three or fewer cases not shown.

The strategies used to estimate the volume of a basketball were coded into 7 categories. Table 6 shows the strategies used, with the frequency, percentage, and the mean estimate by each strategy. It might seem ironic that those participants whose explanation was "I don't know" (strategy 1) produced the closest estimates (6.4). However, a close examination of the data indicated that one participant gave an estimate of 13 and it barely avoided being eliminated as an outlier. This single case considerably inflated the average of the five cases for that category.

Table 6

Frequency, Percentage, and Mean Estimate by Each Strategy Used in Estimating Volume of Basketball

Strategy (n = 85)	f	%	M (L)
1. "I don't know" Or left blank	5	5.9	6.4
2. "I guessed"	12	14.1	4.4
3. "I estimated" or "I pictured it in my head"	10	11.8	3.6
4. Used gallon as a reference and then converted	1	1.2	-
5. Used a 2-liter bottle as a reference	55	64.7	3.7
6. Used formula for sphere volume	1	1.2	-
7. "I saw this number on a basketball"	1	1.2	-

Note. Mean estimates with three or fewer cases not shown.

Of particular interest was the fact that the majority of participants used a 2-liter bottle (strategy 5) as a reference. This is a clear indication that such bottles are probably the most common item in metric measure that a person encounters in daily life in the United States. Nevertheless, estimating with such an item as a reference did not help the participants much in arriving at a close estimate. The reason is likely that estimating volume (3-D) may be much more difficult than estimating length (1-D) and that there are not many chances when one needs to deal with the volume of a sphere in daily life. Furthermore, the shape of such bottles (being tall but thin) may give an inflated impression as to how much they can hold. Without looking at a real basketball side by side with a 2-liter bottle, estimates can deviate considerably.

Discussion and Implications

This section is presented in the perspective of the importance of using the metric system, the importance of training teachers in how to use and teach the metric system, implications for American industries and textbook publishers, and implications for American government agencies.

Using the Metric System

Even though most American preservice elementary teachers do not have many opportunities to use metric measurements in their daily lives, engaging them in using metric measurements, together with being interviewed on and reflecting on using the metric system, can have a positive impact on their perceptions of teaching, learning, using, and converting to it. The reason for this positive impact may be simple: Being engaged in such mental and physical activities involving the metric system increases the awareness of its intrinsic merits such as its consistent use of the base-10 system.

This positive impact on participants' perception of the metric system was the most obvious with the construct of the metric system being important in children's learning of mathematics (see Table 2). It is probably no coincidence that this construct struck a chord with American preservice elementary teachers. Apparently such individuals tend to make an easy connection with the children they are going to teach, and this connection may cause them to ponder on the effect of teaching the metric system on their children's learning of mathematics more than anything else. This probably explains why positive change occurred with this construct but not with the others.

Training Teachers in the Metric System

The results of the two estimation problems suggest that, in general terms, American preservice elementary teachers' knowledge of and ability to use metric measurements is very limited, and many of them have to resort to customary units and undergo a conversion process to express a metric unit. This is a clear indication that, even though both systems of measurements are supposedly taught in schools and given equal treatment in textbooks, American preservice teachers do not appear to be prepared to teach the metric system as well as they do the customary system. Thus it is suggested that the necessity of implementing a component on the metric system in a college course for American preservice elementary teachers be investigated. A required component incorporated into the teacher education curriculum would serve a dual purpose: providing the necessary, systematic training for future teachers before they go into classrooms, and motivating them to learn how to use metric measurements such that they will have sufficient personal experience to relate to in their future teaching of the metric system. This is also consistent with the need for training or staff development in the metric system that the participants in this study expressed. Such sentiment is a good indicator that it will be of great importance that American elementary teachers receive adequate training with regards to using and teaching the metric system.

Implications for American Industries and Publishers

The fact that most participants in this study used a 2-liter bottle as a reference to determine the volume of a basketball suggests a need for items of daily use in metric measurements. It seems to indicate that conversion to the metric system could be less bumpy and find a readier echo in the general public if more merchandise in daily use is manufactured in whole-number metric measurement. Moreover, the inconsistency between the inherent simplicity of the metric system and the perceived difficulty in using it suggests that some form of mandatory use in metric measurements is necessary.

This also brings up another issue: The equal treatment given to both the metric and customary systems in American elementary school mathematics textbooks, though seemingly fair, actually has a rather imbalanced effect. The customary system, with its wide use in everyday life, suppresses any meaningful development of cognition in metric measurements in American children. That, at least in part, explains why numerous attempts to convert to the metric system in the United States have not been successful. The elementary school may be the right place for conversion, and there should be much more treatment of the metric system in textbooks to balance out the use of the customary system in everyday practical contexts.

Implications for American Government Agencies

It is interesting to note that most articles discussing the slow American conversion to the metric system cited cost, fear of inconvenience, and a general reluctance to change (Monroe & Nelson, 2000; Phelps, 1996) while paying little attention to the impact on children's learning of mathematics. Judging from the results of this study, it is now high time for everyone, especially policymakers, to realize the academic benefits the metric system has for America's future generations. Metric conversion is not only good for international trade and commerce and for science and business (Craig, 2012), but also good for American children's learning of mathematics. Moreover, if younger generations are trained in metric system, metric conversion in the United States will be much smoother, as the force for change will come from within after the younger generations grow up. That will be a much easier task than trying to make adults change the habits they have had all their lives.

Limitations

There were several limitations not easy to overcome in the conduction of this study. We are raising two of them here in hopes of aiding readers in their proper interpretation of the results arrived at in the current investigation. The first limitation was, as mentioned earlier in this article, the paucity of research in this regard. We hope that as time goes by, the importance of teaching, learning, using, and converting to the metric system will be more widely recognized and thus more studies will be conducted to investigate this interesting phenomenon. By then, a research design based on a richer data source and with a stronger theoretical framework can be generated and pursued.

The second limitation was the different structure of exposure to the metric system applied to the two different classes of participants in this study. As reported in the methods section, one class received treatment during a span of three weeks while the other classes received the same treatment during a span of a 15-week semester. Although instruction and everything else was the same to both classes, the difference in the timespan of treatment could potentially have different impact. Even though the results were mixed up for the two classes and this study was not designed to compare the two classes, attention is advised in interpreting the related results.

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Appendix A

Interview Questions

1. The United States is one of only three countries in the world that still use the customary system (the inch-pound-gallon system) while all other countries use the metric system (the meter-liter-kilogram system). What is your general feeling about the metric system? Why do you feel that way?
2. Many efforts have been made in this country to convert to the metric system but still we haven't been fully successful. In your opinion, what is hindering this conversion process?
3. What do you think are the benefits of switching to the metric system?
4. In your opinion, who will be most likely helped by switching to the metric system? Who will be most likely hurt?
5. Even if the United States is slow in adopting the metric system, do you see any reason for TEACHING the metric system? If yes, give the reason or reasons you can think of. If no, how do you support your belief?
6. In your opinion, will conversion to the metric system help American students in general? In what way?
7. Suppose you were now a full time classroom teacher and the state mandated the teaching of the metric system during this current school year. Do you feel you could do it well? If yes, cite some specific experience or training you have that you feel would enable you to do it well. If not, what type of training do you feel would be most important to you?

Appendix B

Likert-Type Pro-Metric Questions of the Metric System Questionnaire

For the *metric* system (meters, kilograms, liters, etc.):

I am comfortable in using it.
I am comfortable in teaching it.
It is easier for teachers to teach.
It is easier for students to learn.
It is easier for students to use.

The use of metric system is important …

… in children's development of mathematical concepts in general.
… in children's development of the base-ten number system.
… in children's development of the understanding of place-value.

Teacher preparation programs should prepare future teachers about how to use the metric system.

School districts should offer their teachers workshops on how to *use* the metric system.

School districts should offer their teachers workshops on how to *teach* the metric system.

Switching to the metric system will be useful to American students' future lives.
Students' *learning* of the metric system should be promoted.
Students' *using* of the metric system should be promoted.

Authors:

Fuchang Liu
Wichita State University, Wichita, Kansas, USA.
fuchang.liu@wichita.edu

Mara Alagic
Wichita State University, Wichita, Kansas, USA.
mara.alagic@wichita.edu