

# Measurement Based on Socio-Cultural Background<sup>1</sup>

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We have known that ethno-mathematics is a field of a study that emphasizes the socio-cultural environment in which a person “does” mathematics as stated by D’Ambrosio (Ethno mathematics and its Place in the History and Pedagogy of Mathematics, 1985). Measurement is an important mathematical topic, which leads students to relate math to the real-world applications, particularly with socio-cultural aspects. The purpose of this article is to review the history of the measurement system in Korea briefly and to adapt the measurement system into real-world problems so that children acquire measurement knowledge in the most natural way.

## INTRODUCTION

Rich mathematical contents are inherent in Korean daily lives, especially traditional markets. Because of its mathematical complexities, Korean measurement system can be used to explore the notion of ratio through class simulation, if a teacher brings out-of-school contexts into classroom. Students could measure and compare the tools for measuring items by a variety of units used in their daily lives. We have recognized that ethno-mathematics is a field of a study, founded by D’Ambrosio (1985) that emphasizes the socio-cultural environment in which a person *does* mathematics.

We all agree that measurement is an important mathematical topic, which leads students to relate math to the real-world applications, particularly with cultural aspects. In Korea, having a long history of more than five thousand years, students can experience difficulty in measuring an object in the real life, because there have been various ways of measuring in traditional trading. The metric system and English system were introduced into Korea in 1924. In 1964, the government modified the measurement system based on

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the metric system. Ever since then, the school mathematics across all levels deals with the metric system only, but in the real-world, there is the traditional measurement system still remained. For example, when you go to a traditional market to buy small sized grain such as rice, barley, bean, sesame seed, and so on, people measure them by a “*hop*”(合), whose volume is one tenth of a “*doe*”(升). 1 *hop* is measuring the least amount of volume of grain among the volume units that people prefer to use. Also, people usually need to buy a bigger amount of rice than any other grain because people eat rice for a living, which is measured by *kilograms* and *grams*. Both are used in the real world. The teacher needs to bring out-of-school contexts into the classroom to create a common collection of real-world experience for all the students in the class. The teacher can then facilitate the students’ understanding of mathematics through this experience such as the study of ratio through simulation like buying grain.

History of measurement teaches that observation, intuition, analogy, and induction are the initial and often the most natural ways to acquire mathematical knowledge, ratio. One method that integrates critical reasoning and cultural history is using games of strategy (Gorman, 1997). These kinds of historical ideas help teachers create units that exemplify the NCTM’ Standards (2000) by developing strategies instead of teaching rote rules. Such an activity helps students improve their critical-thinking skills and understand the interconnectedness of our diverse human history. Mathematical developments in other cultures follow different tracks of intellectual inquiry (D’Ambrosio, 1997). An ethnographic approach to the history of mathematics helps a student’s understanding and opens the door to an in-depth study of ethno-mathematics. This approach requires and provides a greater range of connections in the student’s mind.

The purpose of this article is to review the history of the measurement system in Korea briefly and to adapt the measurement system into real-world problems so that children acquire measurement knowledge in the most natural way.

## HISTORICAL BACKGROUND

In the old ages of Korea, people traded their items in markets, which were held once every 5 days. Although different in every region, once a month, there was a bigger market, in which merchants from other provinces came. Korean people started to measure things by a handful amount for measuring the volume, and a length from a thumb to a pinky for measuring the length as their units. This seems to be intriguing that Korean people from the old ages used the height of, arms of, hands of, and feet of a human being body for measuring volume, weight, length of the things as the units of their trading.

Measurement designated a system for calculating amount, size, weight, etc., and therefore it is related with an instrument used for calculating them. In order to practice fair and correct trading or bartering, a standardized measurement is very important. In Korea, a standardized measurement was in practice as early as the “Three Kingdoms” (三國: BC 1c–AD 10c). In *Samguk Yusa* (三國遺事), and *Samguk Sagi* (三國史記)<sup>2</sup>, it is found that “*chi*” or “*chon*” (寸: about 0.8 inch), “*ja*” or “*cheok*” (尺: about a foot) and “*jang*” (= 10 *ja*), were the standardized units were used. King *Taejo* (太祖: period of reign 918–943) of the *Goryeo* (高麗: 918–1392) dynasty adopted the measurement system of *Silla* (新羅: 57BC–935AD) and King *Taejo* (太祖: period of reign 1392–1398) of the *Joseon* (朝鮮: 1392–1910) dynasty accepted that of the *Goryeo* dynasty. King *Sejong* (世宗: period of reign 1419–1450) in the year 1403, who made *Hangeul*, the Korean alphabets, followed the previous standard when he ordered that the confused practice of measurement should be corrected. Therefore, as far as measurement is concerned, it can be retraced back as far as the “Three Kingdoms” until the standardized measurement of King *Sejong*.

However, as the society got complicated, the government needed to control in using a fair measurement system to collect grain and other items for tax. To emphasize the reasonableness and uniformity in measuring, the Korean government developed the measurement system, called “*Do Ryang Hyeong*” (度量衡)<sup>3</sup>, which implies the unit, means, and action to measure.

Even though the government made a uniformed way of using the measurement system and reserved the original instruments for it in the department of finance and commerce, implementing it (*Do Ryang Hyeong*) with the copies of the instruments through the country was not successful, because it was not easy for people to travel around. Communication and information devices were too primitive to spread government’s intention. In such a simple life for living, people did not feel the need to change, and returned in use the old way of the measuring system.

After all, as the modernized era approaches us in 1902, this system of *Do Ryang Hyeong* was renewed by the center that the government supported, called *Pyeong Sik Won* (平式院: 1902–1904), where many ideas of measuring system were imported from the western countries. In 1964, the metric system was announced officially as the measuring system to accommodate with the other countries of the world. However, in the traditional market, people are still familiar with using the traditional system, rather than this modernized metric system.

<sup>2</sup> Both are historical records of the “Three Kingdoms” (三國: BC 1c–AD 10c). Three kingdoms used different measurements, for example, 1 *ja* (周尺) = 20.45cm in *Silla*, 1 *ja* (高句麗尺) = 35.51cm in *Goguryeo*

<sup>3</sup> *Do* (度) stands for length, *Ryang* (量) for volume, and *Hyeong* (衡) for weight.

It is a very similar phenomenon to the case that people in the United States are mainly using the English system, which seems to be dominating in their conversation. If you do not know the English system very well in the United States, you feel like an alien. In a food market of the United States, we always look for measurement labels in the metric system because it is more familiar to me. In *Do Ryang Hyeong*, the most basic unit in length is “*ja*”. There were various kinds of “*ja*” (measuring instrument), with inscribed 1 *ja* (or *cheok*: unit), made out of wood or steel, through the long history of trading. For the most recent one, it is about 0.303 meters long<sup>4</sup>. Especially, the market of textile, in which the Korean traditional dresses are made, uses this instrument, *ja*.<sup>5</sup>



Figure 1. *Ja*: Measuring tool for length

As a unit of measuring area, 1 “*pyeong*” (坪), composed of 6 *ja* × 6 *ja* (1.817 m × 1.817 m) of a square, is to 3.3057 m<sup>2</sup>. Here is a hidden story. People from the old ages thought of a 6 *ja* tall man as the biggest perfect human body they ever imagined. So, the squares of 6 *ja* could be the idealistic area as a unit for measuring.

Table 1. Measuring Lengths and Areas

Lengths	Areas
1 <i>Pun</i> (or <i>Bun</i> ) = 1/100 <i>Ja</i>	1 <i>Pyeong</i> = 36 <i>Ja</i> <sup>2</sup> = 3.3057 m <sup>2</sup>
1 <i>Chi</i> (or <i>Chon</i> ) = 1/10 <i>Ja</i> = 1/33 m	1 <i>Dan</i> = 300 <i>Pyeong</i> = 9.9173 are = 991.73 m <sup>2</sup>
1 <i>Ja</i> (or <i>Cheok</i> ) = 10 <i>Chi</i> = 30.303 cm	1 <i>Jeong</i> = 10 <i>Dan</i> = 3,000 <i>Pyeong</i> = 99.173 are = 9917.3 m <sup>2</sup>
1 <i>Kan</i> (or <i>Gan</i> ) = 6 <i>Ja</i>	
1 <i>Jang</i> = 10 <i>Ja</i> = 3.03 m	
1 <i>Ri</i> = 1386 <i>Ja</i> = 4.2 km (or = 1296 <i>Ja</i> = 3.9273 km)	
1 <i>Sik</i> = 30 <i>Ri</i>	

For measuring weight, there were two kinds of scales:

- One was a balance (Figure 2); Objects are put on one side and weights are put on the other side to keep its balance.
- The other is Stick Scale (Figure 3); Weights are pulled back and forth for a user to find a balance point on the stick ruler.

<sup>4</sup> 1 *Ja* (or *Gop-ja*: 曲尺) is about 30.303 cm. However, 1 *Ja* in *Gorae-ja* (鯨尺) is 1 *Ja* 2 *Chi* 5 *Pun* (about 37.897 cm) in *Gop-ja* and 1 *Ja* in *Goryeo-ja* (高麗尺) is about 45cm.

<sup>5</sup> 1 *Ja* (or *Be-ja*) in textile measurement is approximately 50 cm.

Someone mentions that the merit of using the balance, compared to the stick scale, is that nobody can deceive others by pulling weights back and forth because it should always keep its balance under the same weights on the both sides.

Also, there are three kinds of the stick scales. For small sized objects such as gold, silver, and traditional herbs, they used the smallest stick scale, called “*So Ching*” (小秤). For grain and miscellaneous things, they used the middle-sized stick scale, called “*Jung Ching*” (中秤). For measuring a rice bag, barley bag, or meats of cow and pork, they used the biggest stick scale, called “*Dae Ching*” (大秤).. Later on, in 1902, the Japanese weight system was imported, counted by the units of “*don*” (or “*donjjung*”), “*geun*” (斤), and “*gwan*” (貫). Nowadays, it is easy to see people buy and sell things using this system.

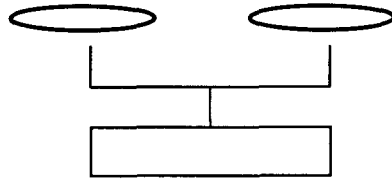


Figure 2. A Balance

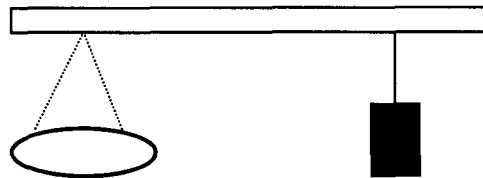


Figure 3. A Stick Scale

Table 2. Measuring Volumes and Weights

Volume	Weight
1 <i>Jak</i> = 1/100 <i>Doe</i>	1 <i>Pun</i> = 1/10 <i>Don</i>
1 <i>Hop</i> = 1/10 <i>Doe</i>	1 <i>Don</i> = 3.75 g
1 <i>Doe</i> = 18.03907 liters	1 <i>Nyang</i> (兩) = 37.5g = 10 <i>Don</i>
1 <i>Mal</i> = 10 <i>Doe</i> = 180.3907 liters	1 <i>Geun</i> = 16 <i>Nyang</i> = 600g (Meat, Sugar)
1 <i>Seom</i> ( <i>Seok</i> : 石) = 10 <i>Mal</i>	[Exception: 1 <i>Geun</i> = 400g (Miscellaneous), 1 <i>Geun</i> = 375g (Jewelry, Candy)]
	1 <i>Gwan</i> = 100 <i>Nyang</i> = 3.75 kg

As mentioned earlier, students have learned only the metric system in school, but

adults including parents talk about things by the traditional ways. They cannot communicate with each other until students are able to convert the figures into the metric system or vice versa. Therefore, Korean teachers should try to bring real-world application into their classrooms to help the students.

As we briefly review the history of measurement in Korea, it was not easy to unify the measurement system as one. We can consider some points of view about the measurement system as follows:

- 1) Ever since the measurement system played an important role as a source of trade between a person to person or a person to authority, measurement instruments needed to be constructed under authority's watch.
- 2) The more we went back into the past; there were a lot of differences in measurement system per regions, since the trading depended on the development of transportation and communication systems.
- 3) Although the measurement system has the same names, each size, weight, amount, etc., became smaller and more precise as time past.

## REAL-WORLD APPLICATIONS

Teachers in classrooms should provide students as many opportunities as possible to get used to converting one system to the other. There are some questions teachers can bring into the classroom.

### *1) Making a traditional dress*

**Problem.** Henna wants to make her traditional skirt with a beautiful color of silky pink. For her size, her mom said that she needs at least 3 *ja* by 5 *ja* because there has to have a lot of ruffles on width. How long should the fabric be, in meters, which she has to buy?

### *2) Renting an apartment*

In Korea, living in an apartment is very common in either city or rural areas.

**Problem.** Jimmy wants to rent a 3-bed room apartment, since he has two children, John and Betty. It should be at least 32 *pyeong* or 36 *pyeong*. Landlord says that the deposit fee is 78,000,000 *won*<sup>6</sup> for a 32 *pyeong*, and 86,000,000 *won* for a 36 *pyeong* per year (in this case there is no monthly rent fee). After the leasing period ends, it is custom that a

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<sup>6</sup> *Won* is the monetary unit of Korea; 1 US\$  $\cong$  1300 *Won*.

tenant will be paid back with the same amount that he/she deposited in the beginning. Which one is more economic for people to lease? Convert these areas into the squared meters ( $m^2$ ).

### 3) *Buying grain*

**Problem 1.** Stella's mom wants to make a Korean cake. She asks Stella to buy 2 *does* of rice, 3 *hops* of black bean, and 2 *hops* of pumpkin flower. Stella is not sure in the quality of the old instruments the merchants use. She needs to know what the weights are in liters because she wants to use her own idea in liters like using a milk carton. Let's tell her the weight of each one in liters.

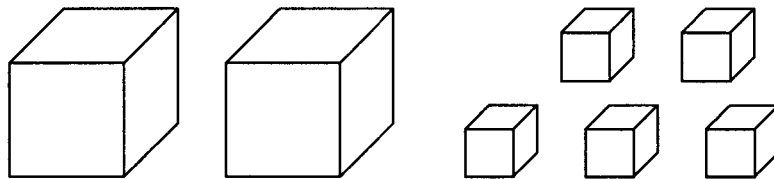


Figure 4. Measuring tool for a volume; *Doe* and *Hop*

**Problem 2.** Stella bought a 25 kg bag of rice from the request of her aunt. What amount of rice, in the old way, could she say she bought for her aunt who uses the old way?

## CONCLUSION

Most countries, including Korea, may have their own traditional ways in measuring things in trade, besides the metric system, which is internationally used. Teachers can use the socio-cultural environment to help a child learn about ratios in more natural and meaningful way, so that children can develop their intuitive knowledge by combing thought, and informal language. By doing so, children are apt to have a chance to understand the need of internationally approved system, the metric system, and to consider more about how it was developed. After identifying the understanding of ratio embedded in the ethno-mathematic knowledge of the children, the teacher can plan lessons that will help them move toward more advanced levels of knowledge and think more formally about those experiences.

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