MARIE SKŁODOWSKA-CURIE AS INNOVATOR AND ROLE MODEL IN THE WORLD

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Abstract: *Today's society is both highly industrialized and matured, entertaining benefits from the fruits of science and technology. Without further advancement in this area, society is likely to stagnate. Specifically, the loss of women's talent through gender stereotyping cannot be resolved without properly resourced primary education services. To stimulate young girls for SET (Science, Engineering and Technology), „Science Studio Marie" has launched a science show program consisting of KAMISHIBAI (Japanese Story Telling with Pictures) performance and experiment presentations for young children, young women and parents. The objective of this article is to elucidate the methodology of science education in the elementary level by Madame Curie, and revive methodology and techniques of her „lost lessons". In 1907-1908, Marie and her colleagues organized a course of lessons for their children. It was called „cooperative lessons". Unfortunately, all the records have been lost and we cannot learn details of her lessons. Just fragmentary information exists and they are sometimes considered as „Madame Curie's lost lessons". One of the Madame Curie's seven missing experimentation lessons lost from the Isabelle's notebook „Leçons de Marie Curie" was closely examined. Dr Tasuo Okano (Dr Eng, Open University of Japan, Emeritus Professor of the University of Tokyo, IIS) and „free fall of substance using bicycle ball bearing".*

Key words*: science education, Leçons de Marie Curie, free fall of substance, KAMISHIBAI, women in SET*

1. Marie Skłodowska-Curie as an innovator and a role model in the world

1.1. Women in Science and Nobel Prize

Needless to say, Marie Skłodowska-Curie (1867-1934) is one of the scientific legends of the 20th century. She was born in Warsaw in 1867 as Maria Salomea Skłodowska. At this time in Japan, Meiji Restoration a great revolution was proceeding. Maria was called „The Radium Woman". Her most famous accomplishment was discovery of polonium and radium. She received the Nobel Prize in Physics with Henri Becquerel and her husband, Pierre Curie. She is the first woman Nobel Prize laureate. Further, the Nobel Prize in Chemistry 1911 was awarded to Marie Curie. She is respected as a role model of women scientists in the world.

Irène, her elder daughter pursued her research and she received the Nobel Prize in Chemistry in 1935. There are approximately 900 Nobel Prize Laureates during

the 115 years. Among them, the Curies are the only example who received the Nobel Prize as mother and daughter.

Since 1901 up to now, there are total 18 women Nobel Laureates in Science. In Physics, Marie Sklodowska Curie is one of two, in Chemistry, Marie Sklodowska Curie and Irène Joliot-Curie are among four laureates. Twelve women laureates are in Physiology or Medicine (Table 1).

1.2. Life of Marie Skłodowska-Curie

Maria Salomea Skłodowska was born in Warsaw, Poland, on 7 November 1867 as the fifth child of Władysław and Bronisława (née Boguska) Skłodowski. Her father was a teacher of physics and mathematics. Her mother was the headmistress of a prestigious school for girls who believed strongly in education. She graduated from the state school with a gold medal at the age of 16. Since the Skłodowska family was very poor, Maria attempted to earn a living through private tutoring, helping with her elder sister Bronia (Bronya). One of her job was governess at the Żorawski estate at Szczuki, less than 100 km north of Warsaw, where she organized a secret Polish primary school for the children of local peasants. Maria came back to Warsaw where together with her father was working at the laboratory of the Warsaw Museum of Industry and Agriculture, learning qualitative and quantitative chemical analysis, chemistry or mineralogy, and gaining practice in various procedures.

Table 1. Nobel Prize of Women in Science (1901-2015)

Field (Number of person)	***Year***	***Name***
Physics (2)	1903	**Marie Sklodowska Curie**
	1963	Maria Goeppert Mayer
Chemistry (4)	1911	**Marie Sklodowska Curie**
	1935	**Irène Joliot-Curie**
	1964	Dorothy Crowfoot Hodgkin
	2009	Ada E. Yonath
Physiology or Medicine (12)	1947	Gerty Radnitz Cori
	1977	Rosalyn Sussman Yalow
	1983	Barbara McClintock
	1986	Rita Levi-Montalcini
	1988	Gertrude B. Elion
	1995	Christiane Nusslein-Volhard
	2004	Linda B. Buck
	2008	Francoise Barre-Sinoussi
	2009	Elizabeth H. Blackburn
		Carol W. Greider
	2014	May-Britt Moser
	2015	Youyou Tu

Source: http://www.nobelprize.org/nobel_prizes/lists/women.html

She left Poland for Paris in October 1891. Maria Skłodowska was 24 years old when she registered as Marie Skłodowska at the Sorbonne to continue her studies. She was awarded a degree in physics in 1893, in mathematic in 1894, and continued to study to pursue a master's degree in physics. There she met Pierre Curie who became both her husband and colleague in the field of radioactivity. They were married on 26th July 1895. The couple later shared the 1903 Nobel Prize in Physics.

Frederick Soddy wrote about Marie that she was „the most beautiful discovery of Pierre Curie." Of course, it might also be said that Pierre Curie was „the most beautiful discovery of Marie Skłodowska" [6].

They shared similar idea about family and society. Marie and Pierre enjoyed their family life with Pierre's father, the young Irène their second daughter Eve and their time with close friends. The Curies believed that it was quite important to let their children benefit from the countryside [6].

On 19th April 1906, Pierre was hit by a horse-drawn carriage on the streets of Paris and died. Marie has been widowed, however, she continued their work. In 1911 she went to Stockholm as the first person ever to be awarded second Nobel Prizes.

From 1907 to 1908 Marie and her colleagues have been organizing so called „cooperative lessons" for their children [4].

During the First World War Maire Skłodowska-Curie organized mobile X-ray teams.

The Curies' daughter, Irène was also jointly awarded the Nobel Prize in Chemistry alongside with her husband, Frederic Joliot in 1935.

As wife, mother and innovator she devoted both to her family and to her scientific pursuits [1].

2. Leçons de Marie Curie: Marie Skłodowska-Curie and Science Lessons

2.1. „Cooperative lessons"

Pierre and Marie shared similar view about family and society. After Pierre's death in 1906, Marie had to look after Irène and Eve by only herself. Marie and her colleagues organized a course of lessons for thegroup of 10 children at age of 9-13 for two years (1907-1908). It was called „cooperative lessons". Later, Irène admired her mother, Marie „The most excellent teacher: Great Science Educator" as well as „Great Scientist".

2.2. „Leçons de Marie Curie"

As mentioned in Life of Marie Skłodowska-Curie, Marie and her colleagues organized cooperative lessons for their children in 1907. Unfortunately the records

have been lost and we could not learn details of her lessons. A note book of her lessons taken by Isabelle Chavannes was accidentally discovered and published with a title of "Leçons de Marie Curie, Recueillies par Isabelle Chavannes en 1907".

Isabelle Chavannes was 13 years old at that time. She was the eldest girl among the students. She grew up to be the world first female chemical engineer.

The notebook was published in 2003, in France. I visited Professor Hélène Langevin-Joliot, a daughter of Irène Joliot-Curie, at the Institute of Nuclear Physics of Orsay in September 2003.

She asked me to translate the book from French to Japanese. With the help of Professors Isao Okada and Tadashi Watanabe I published a Japanese edition of "Leçons de Marie Curie" from Maruzen Publishing Co. on the 7th November in 2004. The 4th edition was released on the 15th October 2015 (fig. 1).

Figure 1. „Leçons de Marie Curie" French, Polish and Japanese edition
Source: photo by M Y Kissho

It shows that Marie has been an outstanding teacher in the elementary education of science. In this book only 10 lessons conducted in 1907 are recorded. It was recognized that the lessons had been continued to 1908. Only fragmentary information have remained after some experiments given in 1908. They are sometimes expressed as „Madame Curie's lost lessons".

In her lessons attention is focused to present to the pupils the phenomena principles and the concept behind them. It is surprising how easily she was able to difficult concepts, principles and theorems for those young students. For Marie Skłodowska-Curie experiments have been the tools for better understanding. The experiments have not been just a show. Without understanding the principles experiments are worth nothing.

2.3. An Analysis of Marie Curie's Science Education from „Leçons de Marie Curie"

Based on records of Isabelle's „Leçons de Marie Curie" I have tried to extract the essence of Madame Curie teaching. „Leçons de Marie Curie" presents 10 lessons, starting with the first lesson entitled: „Differences between vacuum and air" given on the 27th January 1907 to the tenth lesson on „Making Barometer" given on the 14th November 1907. Marie wanted Irène to study when she was very little and wanted her to be a good student.

Marie Curiehas focused on the concepts of „Vacuum" and „Density". Vacuum means that we live in the air and under the air pressure. As far as density: it is very important to understand and learn this phenomenon as first.

Following methodology and techniques that have been found firstly I tried to conduct analysis of Madame Curie's methodology on science education based on records of Isabelle's „Leçons de Marie Curie".

The conclusions of the analysis is that Madame Curie's methodology of science teaching consists of five measures: (1) simplification, (2) understanding of concept and principle/rules, (3) repeating the fundamental concepts and principles/rules and lead young students into the higher level of understanding, (4) demonstration of various aspects of concept for more profound understanding the phenomena with wider perspectives, and (5) visual representation for a better understanding. From these five principles, her favorite technique in teaching was: (1) repeating to memorize, (2) appropriate examples and explanation, (3) lessons composed of appropriate dialogue and questions, (4) application and detailed explanation of equipments, and (5) selection of the phenomena interesting for children.

Figure 2. Eve Curie

Figure 3. „MADAME CURIE"

Source: photo by M. Y. Kissho with courtesy of the Curie Museum, Paris

3. Lost Lessons

3.1. Madame Curie's missing experimental lessons

Free fall of substance with the use of bicycle balls bearing which is the one of the Madame Curie's missing experimental lessons.

Partly preserved record by Eve Curie's "Madame Curie" suggests that there have been following seven experiments, such as (1) free fall of substance with balls of the bicycle bearing, (2) swing of the pendulum; a clock and its regular oscillations, (3) constructing of the thermometer, (4) constructing an electric pile, (5) measure of electrolysis, (6) oxygen combustion, (7) memory arithmetic calculation (Table 2).

Detailed experimental procedures, except mental calculation, have been explained and clarified. All the available information has been used.

Table 2. Marie Curie's seven experiments in record

Items	***Field***
Bicycle ball bearing, dipped in ink, were left on an inclined plane where, describing a parabola, they verified the law of fall.	Dynamics
A clock inscribed its regular oscillations on smoked paper.	Dynamics
A thermometer, constructed and graduated by the pupils, consented to operate in agreement with the official thermometers, and the children were immensely proud of it	Thermodynamics
constructing an electric pile, Marie grew red with anger, "Don't tell me you will clean it afterward! One must never dirty a table during an experiment".	Electrochemistry
measure of electrolysis.	Chemistry
brilliant combustions of oxygen	Chemistry
A virtuoso in mental arithmetic, she insisted on having her protégés practice it: "You must get so that you never make a mistake", she insisted. "The secret is in not going too fast".	Mathematics

Source: {2,7}

3.2. Experiment on Free Fall of a Ball

„Marie Curie's lost lessons in 1908" based on her Science Lessons in 1907 - free fall of substance using bicycle ball bearing, dipped in ink, were left on an inclined plane where, describing a parabola, they verified the law of fall.

Dr. Tasuo Okano (Dr. Eng., Open University of Japan, Emeritus Prof. Institute of Industrial Science, the University of Tokyo) and I elucidate „free fall of substance using bicycle ball bearing" by a developed original hand-made experimental device, for school students, easy to treat: just care for not burn hand and fingers, not to touch heated ball, precise device with using fax thermo paper, instead of ink.

First, we tried to use liquid ink. The surface of a stainless ball rejected liquid, and tracks were not clear. Secondly, we tried to use color powder such as bath powder. The powder was scattered, made the desk dirty. The idea of heated ball and thermos paper came out, which are commodity item of fax paper by trial and error method.

The details of experimental procedure and demonstration are described below.

Materials consists of:

- Balls made of stainless steel (diameter 25.4 mm),
- A Tray for ball,
- An Oven (cooking oven at kitchen available),
- A U-shaped aluminum channel,
- A Hinge,
- An Adhesive Tape,
- Laboratory Jack (size 1500 mm height): 3,
- A Wood board (size 9000 x 12000 mm).

Procedure is following:

The board is covered over fax thermo paper by spray glue. Angle of the slope of wooden board is $\varepsilon = 5^{\circ}$ (Fig. 4) and its inclined angle supported by two laboratory Jacks.

The injection of the ball was made by using tilted aluminum channel and a hinge which is pasted by an adhesive tape. A ball heated by oven approximately 200° C is released at a certain height. (Fig. 5, Fig. 6)

At the end of the channel, it is available to control the injection angle such as 60° , 45° , 30° (Fig. 7) Fig. 3 shows heated balls tracks, and Fig. 4 shows theoretically derived loci initial angles.

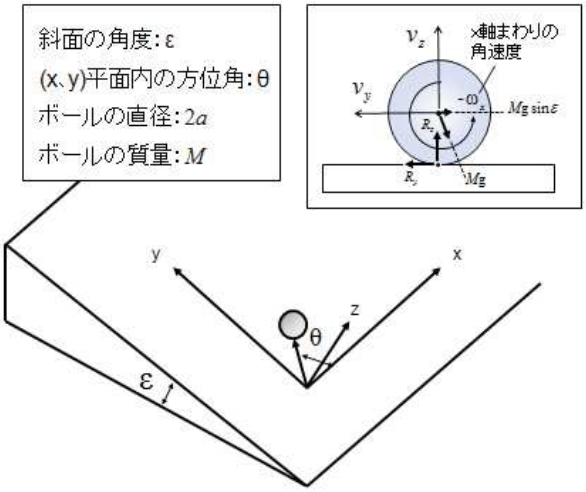

Figure 4. Angle of the slope ε

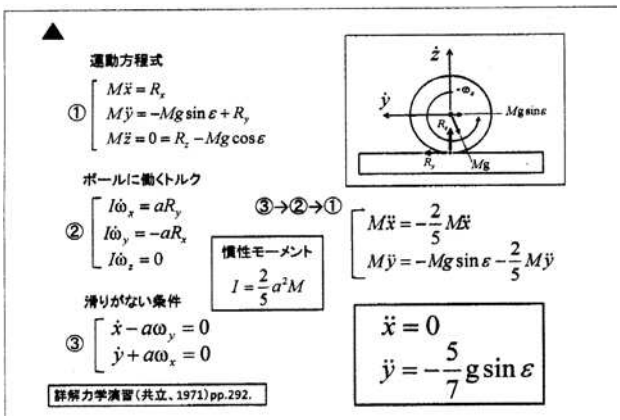

Figure 5. Motion Equation of a rigid ball

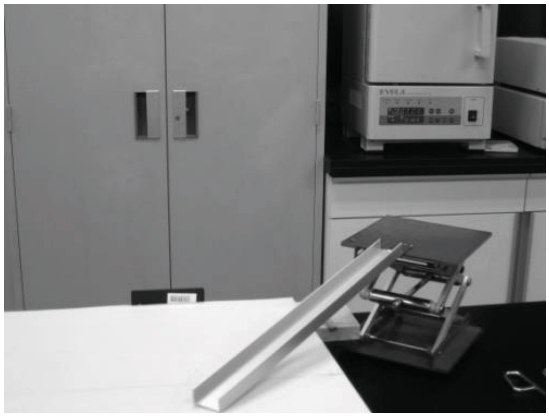

Figure 6. Laboratory Jack and Channel

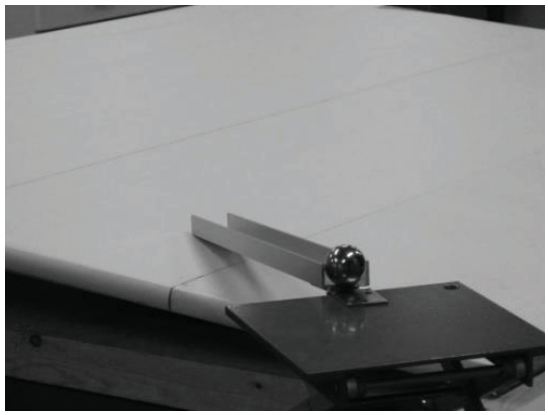

Figure 7. A heated ball placed on Laboratory Jack

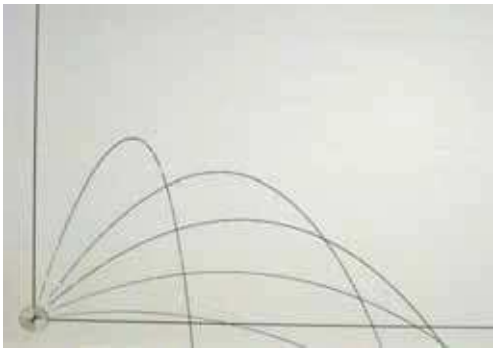

Figure 8. Heated balls tracks

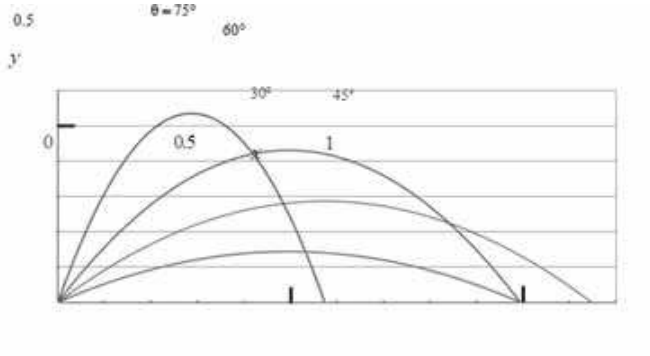

Figure 9. Derived loci initial angle 30º,45º,60º,75º

As Figures 6 and 7 show, a stainless ball which is heated up to 200° C is placed on a laboratory jack. It is rolled on U shaped aluminum channel. The ball marks follows tracks. The potential energy converts into kinetic energy. Initial velocity relates to height of the laboratory jack. Fig. 8 shows heated balls tracks, and Fig. 9 shows derived loci. Refer to Fig. 8 they are matched to the theoretical derived loci of Fig. 9.

4. Conclusions

We are convinced of the simplest assembled device, which is available to get clear fine tracks without scattering ink their hands, fingers and the floor.

Remark: notice to treat heated ball not to burn hands and fingers. This experiment should be done under control with teachers, parents and guardians.

For recreation of „Marie Skłodowska-Curie's experiment: free fall of substance using bicycle ball bearing", this is the most optimized device at present.

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MARIA SKŁODOWSKA-CURIE JAKO INNOWATORKA I WZÓR DO NAŚLADOWANIA W ŚWIECIE

Streszczenie: *Dzisiejsze społeczeństwo jest bardzo rozwinięte technologicznie, a równocześnie dojrzałe, korzysta w pełni z osiągnięć nauki i technologii. Jednak bez dalszego postępu, społeczeństwu grozi stagnacja. W szczególności, problem utraty talentów kobiet wynikający ze stereotypów płci, nie zostanie rozwiązany bez prawidłowego systemu edukacji podstawowej. Aby zachęcić młode dziewczęta do rozwoju w zakresie nauk technicznych i inżynierii, „Science Studio Marie" uruchomiło program naukowy złożony z Kamishibai (japońskie opowiadanie obrazkowe) oraz pokazów eksperymentalnych dla małych dzieci, młodych kobiet i rodziców. Celem niniejszego artykułu jest przedstawienie stworzonej przez Marię Curie metodyki nauczania przedmiotów ścisłych w szkole podstawowej oraz uprowadzenie jej do dzisiejszej edukacji. W latach 1907-1908, Maria i jej koledzy zorganizowali kurs lekcyjny dla swoich dzieci. Nazwano to „spółdzielnią lekcji". Niestety wszystkie dokumenty dotyczące szczegółów realizacji lekcji w ramach „spółdzielni" zostały utracone. Istnieją jedynie fragmentaryczne informacje na ten temat, a całość przedsięwzięcia nazwano „straconymi lekcjami Madame Curie". Na podstawie tych informacji, w niniejszym artykule przeprowadzono dokładne badanie jednej z lekcji (Dr Tasuo Okano - Open University w Japonii, emerytowany profesor University of Tokyo, IIS) i wyjaśniono jej zakres.*

Słowa kluczowe: *nauczanie w zakresie nauk fizycznych, biologicznych i o Ziemi, lekcje Marii Curie, swobodne spadanie, Kamishibai, kobiety w SET (nauka, inżynieria, technologia)*