Status Study on STEM Education Development and Results from Shizuoka STEM Education; many ideas from the observations of Iowa and U.S. STEM; 5 best practices

Yoshisuke Kumano, Tomoki Saito, Jin-Ichi Okumura, Shoko Sakata, Naoko Kosaka & Lely Mutakinati
Graduate School of Science & Technology,
Graduate School of Education
Shizuoka University

I. Insentives of Research in STEM Learning

- Why many countries moving towards to STEM education Innovation ?
- There are so many reasons why we need to move this directions;
  - 21 century skills or competencies;
  - Learning of dynamics of innovation of science & technology or engineering;
  - Changes of Global Society; I of T and I of E;
  - Needs of Governance in Science & Technology (connected with NOE; nature of science & technology)

1. Contexts of Science Education in Japan was revised; Present Situation;

(1) The Present Course of Study of Japan; Elementary School started from 2011, Middle School started from 2012, High School started from 2013.

(2) Every 8 to 10 years, we have been revising our course of study in the recent 4 to 5 decades; so then next target year; 2018.

(3) On 2014 we had designed new frameworks for the next decade. On 2015 special task force meeting on Science Education has been conducting at MEXT(Japanese Ministry of Education).

1. Contexts of Science Education in Japan

（１） Basic Characteristics of present Course of Study;

/ Challenging to highly knowledge intensive society; knowledge creation system in science and technology;

/ Education for the sustainable society.

/ Formative or Authentic assessment

/ Focusing on more inquiry base learning;

1. Contexts of Science Education in Japan

（2） 2011 science and technology white paper: focus on “Governance”

Accepting the argumentations which are subjective wills from each stakeholders into the policy formation that was developing by the communication and discussions among government careers, scientists & engineers communities, business communities, local communities and nations in Japan.

"Science and technology in the contexts of the society",

1. Contexts of Science Education in Japan

(3) 3.11 Natural hazards; Higashi Nippon Giga Earthquake, Huge Tsunami Disaster and the Fukushima Nuclear Plant Explosion cause the strong reexamination of frameworks of education.

(4) Innovative Science & Technology or Engineering oriented educational challenges supported by JST such as SSH (Super Science High Schools), SPP(Science Partnership Project), Science Competition among High Schools, so-called Kagakuno Koushien.

1． New Contexts of Education in Japan towards 2018;

- Active learning in all subjects and programs.
- 21st Century Skills or Competencies
- Problem Based Learning and Project Based Learning

(STEM learning was pointed out at 2016 MEXT Executive Meeting; however, STEM learning is not major area in science & technology education)

More and more research funding for STEM learning;

＊ Japanese NSF fundings for STEM education researches were getting increased in a small sized, however, still within 15 groups, where as, "STEM Cells" researches are more than 100.

- For that reason, we can say that we are starting stages in terms of STEM education research in the contexts of Japan.

3. Science & Technology Governance

According to the World Bank Analysis, Japan was counted No.8 from the top among 21 countries.

As part of "the governance" of the country, science & technology governance plays important roles for the society. On the same direction science & technology governance should be imbedded into the framework of science & technology education.

Status of Japanese STEM innovation

One of the characteristics of Japan concerning to STEM is that government focused more on the innovation of STEM area, so-called "Japan-Innovation".

Under the MEXT, you can find so many projects among scientists, engineers and technologists in all of the country. Especially, in order to break down all of the parts of the melt-down power plants, we need to develop high quality robotics and radiation protection technologies which can work at the severe radiation environment for example

So many science & technology specialists in Japan are heavily understand the importance of STEM innovation; however, we/they are not realizing the importance of STEM education innovation in the K-16 education.

Status of Japanese STEM innovation

So, in Japan there are a few task force institutions and researchers in the area of STEM education innovation or we can say that we are just starting the innovation of STEM learning. This year of 2016, there are about ten research groups who are in the research processes connected to STEM education with JSPS(Japanese NSF).

Also, the institutions where STEM education center existed are only two universities;
Saitama University and Tamagawa University.

Shizuoka University got the grants for STEM education from JST(Japan Science and Technology Agency) for the second times and Shizuoka University is planning STEM innovation for graduate school courses.

Shizuoka University has been working to develop workable model in the contexts of Japanese education for three years.

Status of Japanese STEM innovation

What we have been investigating on STEM are;

(1) what is the nature of STEM education as the innovation of science education? : theoretical analysis,

(2) what are the major processes of three dimensional learning influenced by NGSS(Next Generation Science Standards)? : practical analysis,

(3) For the Japanese contexts for the innovation of science and technology, we need to develop unique theory and model needed for STEM learning in the informal education setting and formal education setting.

We are finding the NGSS has direct connection with STEM education innovation. We would like to develop evidences that STEM education can develop well in terms of 21st century skills or competencies.

3.1 USA Science Education Movement From the years 2011 to 2014

" A Framework for K-12 Science Education, Practices, Crosscutting Concepts, and Core Ideas," published in October , 2011.

3. 2. Outcomes of New Framework of Science Education in the US after 2011

- defining engineering, technology and applied science and settled down into science education.

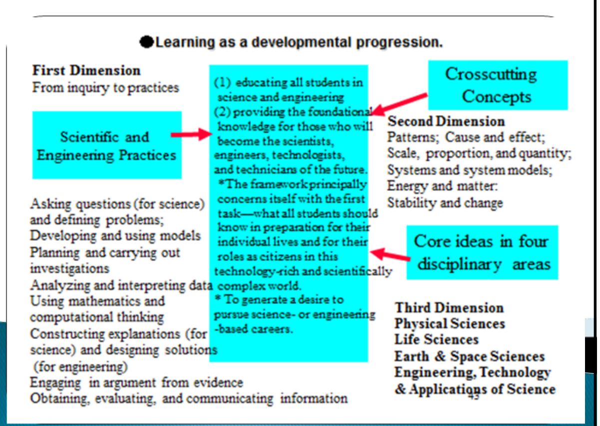
-"practices was introduced as the terminology for inquiry in science education. Hands-on experiential activities of science and engineering are included.

- based on the developmental stages of children and progresstions understanding in learning (learning progressions) existed in each dimension is very important. (I found some criticisms are also coming up)

3. 2. Outcomes of New Framework of Science Education in the US after 2011

- Selection of crosscutting concepts was made, and those important concepts were from the big ideas as shown in the previous national science education standards(NSES) and AAAS benchmarks covering science, engineering, and technology.

- Careful selections of learning core concepts in learning were made. These are physical science (physics and chemistry), life science, earth and space science and engineering, technology and applied sciences.



Three Dimensions;

1st Dimension; Science & Technology Practices;

1. Asking questions(for science) and defining problems or issues(for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constucting explanations (for science) and designing solutions(for engineering)
7. Engaging in argument from evidence.
8. Obtaining, evaluating, and communicating information.

2nd Dimension;

1. Patterns.
2. Cause and effect;
3. Scale, proportion, and quantity;
4. Systems and system models.
5. Energy and matter:
6. Structure and function;
7. Stability and change.

3rd Dimension; Four contents in K-12 Framework

1. Physics and Chemistry;
2. Biology;
3. Earth & Space Science;
4. Engeering, Technology, and Applied Science.

3.2. New Framework of Science Education in the US after 2011

-all students have some appreciation of the beauty and wonder of science;

-possess sufficient knowledge of science and engineering to engage in public discussions on related issues;

- are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school;

3.2. Table 1.; Definition of Engineering

Technology	any modification of the natural world made to fulfill human needs or desires.
Engineering	a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants.
Application of science	any use of scientific knowledge for a specific purpose, whether to do more science; to design a product, process, or medical treatment; to develop a new technology; or to predict the impacts of human actions.

3.3 Next Generation Science Standards

Due to the construction of the framework of science education for the next generation, Next Generation Science Standards were developed. NGSS were developed by the 41 headquarter committee members and the cooperation with the26 States based on the “A Framework for K-12 Science Education”.

3. Governor’s STEM Advisory Council; State of Iowa

● http://www.iowastem.gov/

Total Budgets; 4.7 billion dollars (State Funding+NSF)
●STEM Scale Up Programs for 2012-2013, http://www.iowastem.gov/stem-scale-programs-2012-2013#overlay-context=
●STEM Scale Up Programs for 2014-2015
http://iowastem.gov/sites/default/files/evaluation/2014-15%20Iowa%20STEM%20Evaluation%20Report.pdf

6. STEM Education Center;

● http://www.cehd.umn.edu/stem/
(from NSF 8 Million Dollars)

● Minnesota STEM Teacher Center http://www.scimathmn.org/stemtc/)

● The Minnesota STEM Network http://www.scimathmn.org/index.htm

● WashingtonSTEM

○ STEM Education Coalition;
http://www.stemedcoalition.org/

STEM education; Systemic Reform
STEM graduates; target; 1 million people
STEM teachers preparation
STEM in-service teacher preparation

Preparing a 21st Century Workforce Science, Technology, Engineering, and Mathematics (STEM) Education in the 2013 Budget

How can we find any interesting evidence of/with the framework of NGSS?

1. Design of J-STEM Projects in the local setting.
2. Proposing with the Action Researches Planning to any sources.
3. Starting from informal science education from June, 2013.
4 Five Ph.D. candidates collected all of the data from teachers and students.
5. Four locations with about 20 students from 5th to 9th grades at Shizuoka area.
6. e-learning with moodle for the support of researches among students.

What we learned this time from two schools;

- Harvert Hoover High School; STEM Administrator, Maureen Griffin showed many interesting ideas for the implementation of STEM learning innovation.
- Thresa Chatholic School; the Princepal, Ms. Stemler Ellen showed many interesting ideas for the implementation of STEM learning innovation.

What we learned this time from other states;

- WashingtonSTEM; As the state, we found very interesting developments many area in the State of Washington;
- University of Minnesota; As the STEM Researches, University of Minnesota, STEM Education Center is developing many interesting researches and papers.

For the outcome of 2016, our team will develop our own analysis within three months.

High School Teachers Response Towards STEM Education"

Yoshisuke Kumano, Tomoki Saito, Ilman Anwari, Irma Rahma Suwarma
Graduate School of Science & Technology, Faculty of Education, Shizuoka University

Study from 2014

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5. In-service Teacher Training and the Response Towards STEM Education

On 3rd July, 2014, it was conducted teachers in-service high school science teachers training at Mishima-City, Shizuoka Prefecture supported prefectural Board of Education.

Pre and post questionnaire were conducted at the starting point and ending point of the special lecture on STEM education. 43 high school teachers responded for the questionnaire basically. (Appendix 1 in the handed paper.)

5. In-service Teacher Training and the Response Towards STEM Education

Table 1: Towards to Science (n=40)

	fascinating	appealing	exciting	Mean a lot	interesting
Pre-	4.53	4.68	4.35	4.58	4.75
Post-	4.75	4.80	4.55	4.63	4.75
Paired T-test	0.014				

Table 1 shows that teachers changed their attitudes towards science and they realized that science was identified more interested and exciting area of study when science connects to STEM.

5. In-service Teacher Training and the Response Towards STEM Education

Table 2: Towards to Mathematics (n=43)

	fascinating	appealing	exciting	mean a lot	interesting
Pre-	3.88	3.86	3.58	4.23	3.86
Post-	3.95	3.98	3.84	4.26	4.07
Paired T-test	0.082				

Table 2 shows that teachers changed their attitudes towards Mathematics and they realized that Mathematics was identified more interested and exciting area of study when they connected to STEM, however the means are the lowest than the mean of STEM.

5. In-service Teacher Training and the Response Towards STEM Education

Table 3: Towards to Engineering (n=37)

		fascinating	appealing	exciting	mean a lot	interesting
Pre-	Pre-	4.51	4.49	4.03	4.41	4.35
Post-	Post-	4.68	4.70	4.41	4.62	4.62
Paired T-test	Paired Ttest	0.0007				

Table 3 shows that teachers changed their attitudes towards Engineering and they realized that Engineering was identified more interested and exciting area of study when they connected to STEM. Also the means are similar to the means of Science.

5. In-service Teacher Training and the Response Towards STEM Education

Table 4: Towards to Technology (n=43)

	fascinating	appealing	exciting	mean a lot	interesting
Pre-	4.49	4.63	4.03	4.60	4.57
Post-	4.83	4.77	4.46	4.74	4.69
Paired Ttest	0.0036				

Table 4 shows that teachers changed their attitudes towards Technology and they realized that Technology was identified more interested and exciting area of study when they connected to STEM. Also the means are similar to the means of Science and Engineering.

5. In-service Teacher Training and the Response Towards STEM Education

Table 5: Towards to STEM Careers (n=43)

	fascinating	appealing	exciting	mean a lot	interesting
Pre-	4.12	4.23	4.00	4.37	4.26
Post-	4.21	4.28	3.95	4.42	4.40
Paired Ttest	0.52				

Table 5 shows that teachers did not change their attitudes towards STEM Careers and they did not realized that STEM Careers were not identified more interested and exciting area of study when they connected to STEM. These means the workshop on STEM does not effect the attitudes on STEM careers.

5. In-service Teacher Training and the Response Towards STEM Education

Table 6: Towards to STEM Integration (n=43)

	Appealing	Mean a lot	Interesting	Beneficial	active	Understandable	Necessary	Good	familiar	Strong	Expanding	More	simple	Fast	Easy
pre	4.30	4.47	4.44	4.19	3.84	3.74	4.47	4.33	3.65	3.63	3.88	3.72	3.67	3.93	4.09
post	4.58	4.51	4.51	4.35	4.14	4.16	4.44	4.37	3.95	4.02	4.21	4.00	3.56	3.98	3.74
	P.t-test	0.03													

Table 6 shows that they identified STEM education were appealing, meaning a lot, interesting, beneficial, active, understandable, strong and expanding, however, STEM education was not active, understandable, strong, simple, and easy. It is interesting to find that only the attitude scale of "easy" moved to smaller mean after getting information on STEM education..

5. In-service Teacher Training and the Response Towards STEM Education

From the results of STEM FD for high school science teachers in Shizuoka and the pre-post questionnaire, we could find the following results.

- Teachers can identify the importance of STEM education area, however, they may not realize the importance of integrative lessons in science education, also, they may not understand the importance of STEM careers yet in Japan.

Shizuoka STEM Lessons at Attached Junior High School at Shizuoka University"

Chair, Yoshisuke Kumano, Ph.D.
(Shizuoka University)

2013, 2014, 2015, 2016

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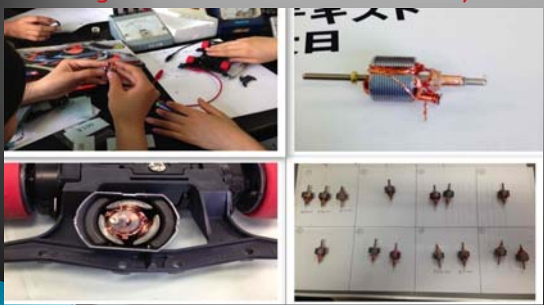
ISMTEC 2014, 7-9 November,

Shizuoka STEM Lessons at Attached Junior High School at Shizuoka University"



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6. Shizuoka STEM Lessons at Attached Junior High School at Shizuoka University

The 158 9th grade school students (four classes), divided into 10 groups in each class. The lessons involved making a DC motor that was faster, more stable, more efficient, and cheaper. In this activity, students had to think about using a budget to buy the parts of the DC motor and conduct several trials (like team of scientists and engineers). The problem of the lesson sequence was related to real world activities, where motors have many functions in vehicles and machines.

6. Shizuoka STEM Lessons at Attached Junior High School at Shizuoka University

First, students had to measure the current and voltage of each battery (alkaline and Ni-MH batteries) and the different diameters of cupper wire (0.32 mm, 0.4 mm, and 0.5 mm). It was expected that students would understand the reason for carrying out these measurements after comparing the differences of each motor. During this time, students engaged in argumentation according to the data from their measurements.

6. Shizuoka STEM Lessons at Attached Junior High School at Shizuoka University

As a result, they concluded that low resistance would generate low power. This conclusion differed from those of other groups that stated that a thick wire had low resistance and would generate greater acceleration and speed. Finally, they checked several articles related to the design of a DC motor and concluded that according to electromagnetic principles (application of scientific concepts), a thick wire, an increased number of windings, and a strong magnet were needed to design a high-performance motor. However, they did not think about the heat (engineering).

6. Shizuoka STEM Lessons at Attached Junior High School at Shizuoka University

Most of the Japanese middle school science are ignoring these STEM activities because these activities are time consuming and also most of the science teacher believe that integrated learning such as STEM education may cause to be just enjoying game and losing the focus of understanding important scientific concepts.

ISMTEC 2014, 7-9 November,

Shizuoka STEM Junior Science Project "Summer STEM Camp"

Chair, Yoshisuke Kumano, Ph.D. (Shizuoka University)

2013, 2014, 2015, 2016

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6. Summer STEM Camp ..

●Students from three cities; Shizuoka, Yaizu, and Funieda Cities; about 40 students on 2013.

● Students from four cities; Shizuoka; Hamamatsu, Fujieda,and Mishima about 25 students on 2014.

● Students who attended were from three cities; Shizuoka, Yaizu, Fujieda; about 25 students on 2015.

- Chair; Yoshisuke Kumano, Ph.D.
- Shizuoka STEM Junior Projent "Shizuoka STEM Camp"
- Date ; July 29th – 30th, 2013, July 30th-31th, 2014, December 23rd – 25th, 2015,
- Project Purpose ;

We have been having very strong relationship among Shizuoka Children's Museum, Shizuoka University, Shizuoka Board of Education. We have been collecting STEM learning Materials and designing the two days program.

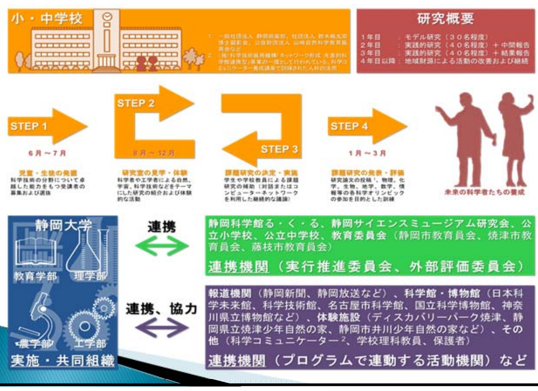
Target purpose was to provide students learning of both science inquiry and engineering practices and encourage and guide students to develop group or individual science inquiry by themselves, and to use more mathematical thinking with the help of graduate students and professors through Moodle system.

6－２. Expecting Outcomes

The quality of each scientific researches and engineering practices would be incredibly deepen. Also, students would be able to attend science and technology classes with higher interests at schools.

Our team did submit funding planning to the JSF competition so –called "the Education Project for 2014 Next Generation Scientists". We got 50,000 US $ for the STEM Project for 2014 activities and 17,500$ for 2015.

6. planning to the JSF competition so -called "the Education Project for 2014 Next Generation Scientists" **STEM Camp**



6. STEM Summer, Autumn Camp

Summer Camp：Ikawa, Shizuoka
Autumn STEM Camp：Yaizu, Shizuoka

Challenging Integrating area of STEM
Meeting with real Scientists or Engineers
↓
To be the future scientists or engineers who will challenge science & technology isuues in the contexts of society !

Main theme：Ikawa Summer Camp
「How cam we conserve the nature towards preservation of the nature by developing good STEM system. 」

Main Theme: Yaizu Autumn Camp
"Challenging issues which will occur after huge earthquwake and tsunami using STEM area innovation in your area. "

Leaning from Iowa

- NGSS adapted to the Iowa Science Standards
- This time we visited;
- Harvert Hoover High School; STEM Administrator Griffin Maureen and her team showed many applicable STEM ideas for Japan.
- Thresa Catholic School; the Principal, Stemler Ellen showed also many applicable STEM ideas for Japan.

Leaning from Iowa

- We will alalize carefully within three months;
- We have visited; the State of Washington; the State of Minnesota; the State of Iowa;
- We have been funded for three years from 2016 to 2019 in a small scale, however, STEM learning innovation will be expanded year by year.

8. Challenges and Future Perspectives

●For the country of Japan, we are still within the great difficulties after 3.11 and nuclear energy plant accidents and we are planning for next innovation of education including science education.

- STEM education can be wonderful model for our nation, Japan. In order to create and invite good models, we need to develop pilot researches within the contexts of our culture.

8. Challenges and Future Perspectives

●In order to create and invite the concepts from engineering education and Mathematics into science education, how our science lessons should be changed into what models?

How many evidences can we develop which empower students to develop better innovation in the area of science & technology(STEM area) and also empower science & technology governance in the near future?

8. Challenges and Future Perspectives

●At the headquarter committee for the developing next framework of education, major focus is to develop 21 century skills or competencies in all subjects with PBL.

● Not much discussions are coming up in STEM area, yet, however, all of the people in Japan are getting agree to develop Project & Problem Based Learning or Research Based Learning.

Thank you very much
for your time to share
with us.
ご清聴ありがとうございます。