# Virtual STEM Class for Nuclear Safety Education in Metaverse

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# Virtual STEM class for nuclear safety education in metaverse

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**Abstract**

The blend education of e-learning and hands-on activity was carried out, using Metaverse. The topic was picked up, relating to radioactivity, nuclear safety education and STEM education. The students were six 5th and 6th graders in an elementary school. The lecture was given to them through the virtual class in Metaverse (Second Life). And then, the hands-on experiments relating to radioactivity were carried out in real life, lead and guided by the teacher in Second Life synchronistically and supported by the teacher in real life sometimes. The questionnaire given to each of students after the hands-on experiments showed very clearly that the project satisfied with the original goals very well, from both viewpoints of STEM education and nuclear safety education at early stage (pre secondary) levels. We concluded that the blend education worked well for STEM education to much extent.


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Keywords: STEM, virtual Class, Metaverse, Second Life, Nuclear Safety

## 1. Introduction

STEM Education has been already a buzz word in the US society[1], [2]. It is never any concrete education methods, but a comprehensive educational concept. It is an acronym for the fields of Science, Technology,

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Engineering and Mathematics. Usually, the educational concept has been used to boost up those fields particularly at pre-college levels. The importance leads to the prosperity and rigorous development directly. Therefore, the STEM education is the most important one for the future generation, so that the nation could survive with abundant prosperity. As described above, it can be defined as early-stage science and engineering education, even though it actually might extend to post-secondary education. The STEM education is expected to play an important role for creative engineering education which should be the core of engineering education. Since the many portions of STEM education are related to early stage and pre-secondary education, the factor such as joyfulness, entertainment, having fun etc. would be very important for the successful outcomes. Therefore, we were trying to introduce Metaverse into the STEM education in this project. Metaverse is the virtual 3-Dimensional World[3]. We have investigated many possibilities so far[4]-[8]. When it would be applied to e-learning, one of the remarkable advantages is clearly that students could have the sense of reality during virtual classes. The factor could make up for one of the serious weak points of e-learning. However, in this study, we dealt with the e-learning class for elementary school children (11 and 12 years old students). The use of Metaverse was doubtful and still controversial for the educational purpose due to their age problem. And actually, their computer and internet literacy were still at the beginning stage. Therefore, we made the plan composed of both virtual and real sides. Actually, the part of lecture, guidance and leading for the project was assigned to the virtual side, while the hands-on activity to the real life exercises. It means that this pilot project could be defined as the blend education project of e-learning and real hands-on activity for early stage students. We carried out the blend education to investigate if the blend arrangement for STEM education would work well or not. The results were discussed from the viewpoint of both the system availability and also the STEM education.

## 2. Experimental

### *2.1. Topic and lecture*

The topic for the project was chosen in nuclear energy education. We had the two reasons for the selection. Three years ago, we had a disastrous Tsunami followed by a giant earthquake in Tohoku district of Japan. Tsunami destroyed the Fukushima Nuclear Plants and the radioactive pollutant began. The aftermath is still very serious and strong. Lots of people here in Japan are afraid of radioactivity psychologically, physiologically and mentally. The discussion on the topic is now going on nationally from those viewpoints. However from the viewpoint of engineering and technology, it should be very important to make sure what would be dangerous and what would be safe. Otherwise, the discussion might be impeded by emotion and loose the objectivity. Therefore, the nuclear education is the most important topic also for STEM.

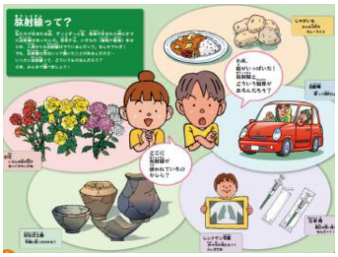


Fig.1 A slide explaining about what is radio activity.

Fig.2 Apparatus used for this project.

The other reason is that we authors have dealt with the related topic in the past. Then the students were at the secondary education level. Even though the students for this project were elementary school students, we could utilize the know-how and experiences in the past for this current project.

In this project, the lecture was carried out in Metaverse (Second Life). The teacher used a power point file for his lecture on second life. Fig.1 shows the second slide of the lecture file. Radioactivity exists even in nature, even though the place might be far away from any nuclear plants. This slide showed children the truth very easily.

In this project, students measured radioactivity for various materials not in virtual life, but in real life. Students used simple radiation counters. Fig. 2 shows the apparatuses used for the experiments after the lecture.

Fig.3 shows how radioactivity could be shielded by various materials and also how it would decay with distance from the radioactive source. Then he explained with some slides how students should carry out hands-on activities. The slide show was composed of all of those items.

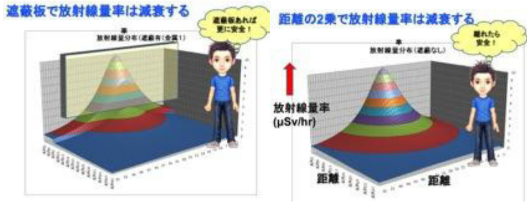


Fig.4 Appearance of the virtual classroom.

Fig.3 A slide showing the characteristics of radioactivity.

The classroom was prepared on the virtual island run by Nagaoka University of Technology (NUT). Fig. 4 shows the appearance. Even though it was made virtually by Linden Scripts, it had white boards, teachers and students desks, chairs etc. just like the one in real life. The situation made sure for participants to have a sense of reality and it was expected to increase learning effects, motivation and drive for learning. Students were looking at the classroom and listening to teacher's lecture. In the past, it was hard for us to communicate verbally. Then the chatting based on text messages was the main stream of communication. However, the aural communication became easier recently. Therefore, all of the information exchange such as lecture, questions, answers, communications etc. in this experiment were carried out, using voice functions of Second Life.

## 2.2 Experimental procedure

Fig.5 The class setting for students.

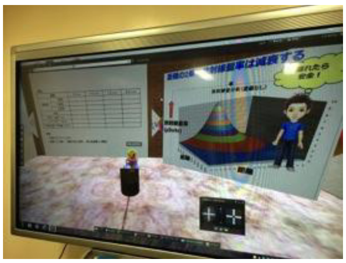

Fig.6 A lecture scene in the virtual class.

Firstly, Kobayashi, one of us authors, gave a lecture on the second life. He used his terminal PC at his office in Tsuyama, Japan. The materials for the lecture were prepared in advance as slide show in advance and put on the screens in the virtual classroom. It continued in about 30 minutes. The number of students participating the project was 6 (three boys and three girls) who were elementary school students at 5th and 6th graders from Sarakujima Elementary School in Suzuka, Mie, Japan. Since all of the participants were under 20 years (legally they are considered "infancy"), Kanematsu, another author for this paper, joined the virtual classroom on behalf of them, as shown in Fig.5. Students joined the classroom behind the terminal PC and the big screen set in Suzuka. We could avoid some legal and educational potential troubles easier, using this system.

After the lecture, students tackled with some hands-on activities. All of the experiments were composed of measuring radioactivity for various situations. Firstly, students measured the radioactivity from some samples (granite, common salt, bath agent, fertilizers etc.), using the simple radioactive counter. Secondly, they measured how it changed with distances from the sample source. Thirdly, They measured how the radioactivity were decayed by various shielding materials such as lead, acryl, aluminum, stainless steels.

After all of the hands-on activities, the questionnaire were given to the students. They answered all of them and submitted to us in real life. The results were summarized and analyzed in this paper. All of these activities were described and discussed in the following section.

Fig.7 Measurement of radioactivity for various samples.

Fig.8 Measurement of radioactivity decay with distance.

## 3. Results and discussion

Fig.6 shows what the lecture was going on in the virtual class. In the lecture, the teacher gave talks about the fundamental principles and some information which would have been needed for the following hands-on activities. However, the hands-on experiments after the lecture were also lead and guided by the teacher in the virtual classroom. And the real life teacher with students helped them carrying out the experiments. Fig. 7 shows the students measured the radioactivity of various samples, while Fig.8 shows the students were tackling with measurement for the decay of radioactivity with the distance from the sample sources. After the lecture and experiments, the questionnaire was given to each student and they answered all of them.

The questions constituting it were those as follows.

1. **Did you enjoy the experiments?**
a. Very much. b. Pretty much c. neutral d. Not so much e. not at all
2. **Was your teacher on the second life friendly to you?**
a. Very much. b. Pretty much c. neutral d. Not so much e. not at all
**3. Was your teacher in the real life friendly to you?**
a. Very much. b. Pretty much c. neutral d. Not so much e. not at all
**4. Was it easy for you to understand the lecture on Second Life?**
a. Very much. b. Pretty much c. neutral d. Not so much e. not at all
**5. Did you understand how radioactivity looked like?**
a. Very much. b. Pretty much c. neutral d. Not so much e. not at all
6. **Did you understand how we could be safe against radioactivity.**
a. Very much. b. Pretty much c. neutral d. Not so much e. not at all

**7. Do you want to carry out similar experiments relating to radioactivity?**
a. Very much. b. Pretty much c. neutral d. Not so much e. not at all
8. **Feel free to write anything for this project.**

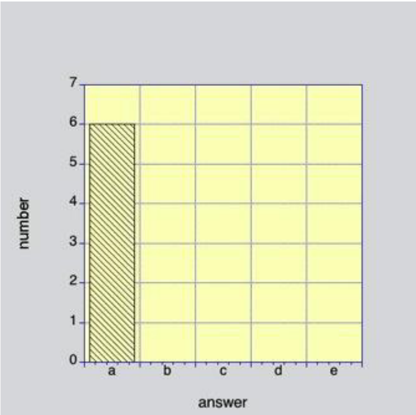


Fig.9 The results for question 1.

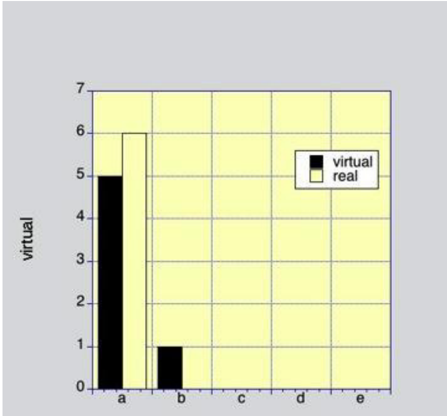


Fig.10 The results for question 2.

Fig. 9 shows the result for the question 1 (Did you enjoy the experiments?). The figure shows obviously all of the students enjoyed this project. We presume this could be explained by a special reason, in addition of the interesting contents. Students were excited by the avatar and the virtual three dimensional space very much. After the activity, students were hard to leave the classroom and continued to operate avatars in a pretty long time. Therefore, the Metaverse (Second Life) could work well for this STEM Education. Generally, the

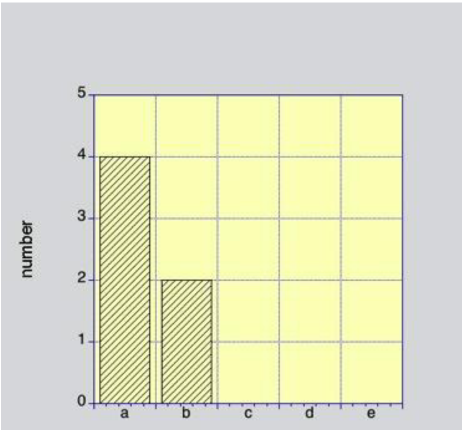


Fig.11 The results for question 4.

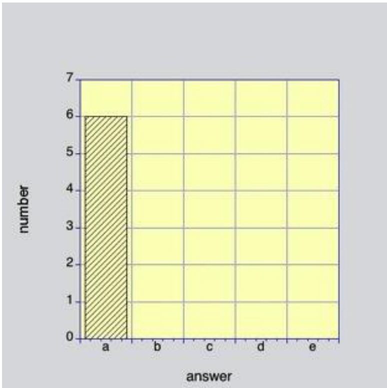


Fig.12 The results for question 5.

concept of radioactivity must be very hard to understand particularly for elementary school children. Also for such a difficult educational materials, the Metaverse could be an effective supplemental effect to get the educational outcome.

Fig.10 shows the results for the question 2 and 3 together in one figure. Both teachers in virtual class (black painted bars) and real life (white painted bar)could make students have fun. Since having fun is the most important factor for STEM education, this result

Fig.11 shows the result for the question 4. Their understanding must be helped by the second life setting and teachers friendliness very much.

Fig.12 shows the result for the question 5. As well as Fig.11, they understood about radioactivity completely, even though the understanding might be fundamental.

Fig.13 shows the result for the question 6. This figure shows all students understood the nuclear safety very well. In this project, two kinds of safety were taught through actual experiments. One of them is the "distance" effect. Being away from the radioactive source is one of the ideas how we could be safe against radioactivity. They carried out the experiment how the radioactivity decayed the distance as well as listened the lecture. The other is the "shielding" effect. They understood through the experiment that some kinds of metals such as lead could protect radioactivity effectively. This project was STEM education, while it was the education for nuclear safety at early stage education standard. From the viewpoint, the experiments were successful for the double reasons.

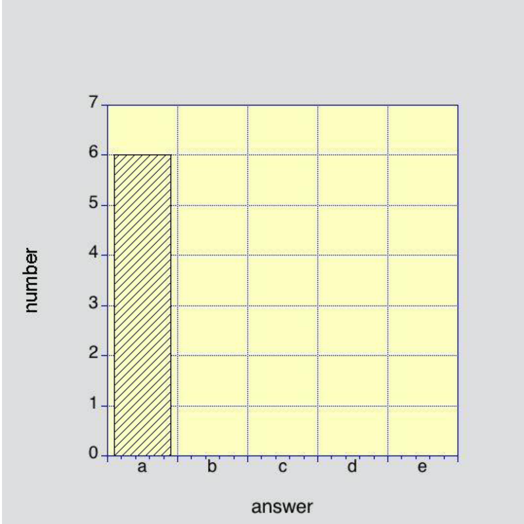


Fig.13 The results for question 13.

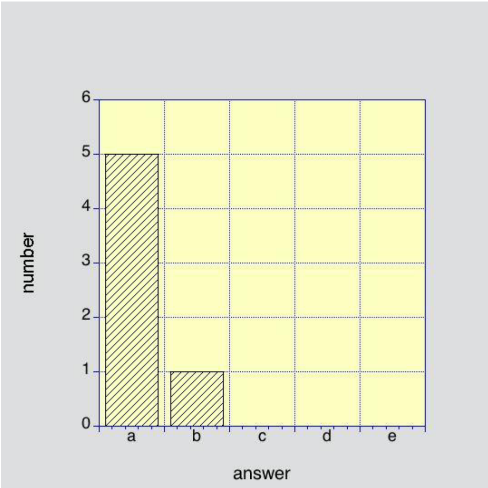


Fig.14 The results for question 14.

Fig.14 shows the result for the question 7. The figure shows very clearly that all of the students were positive for the second chance of the similar experiments in Metaverse.

Regarding question 10, all participants wrote about their impressions, ideas, very positively, shown in Table 1.

Table 1 Participants' free impressions

| students | Free impressions |
|---|---|
| A | I understood various matters generated radioactivity and also their concrete values. If I could hide myself behind the lead shield, I could guard me against radioactivity. I was very surprised to see it. |
| B | I was very surprised to protect radioactivity with lead plates. I was also much impressed the radioactivity decayed with the distance. I was very happy to know various topics relating to |

| | |
|---|---|
| | radioactivity. |
| C | I understood radioactivity was not so dangerous, when I could be far away from the source. In addition to that, I understood the shielding materials between the radioactive source and me could mitigate the radioactivity effectively. I enjoyed the activity and project very very much. At the same time, I felt very strongly that I had better learn English to have fun in Internet. |
| D | Teachers are friendly and I could learn a lot about radioactivity very easily. I enjoyed the class very much. I would like to join such an activity once again in the future. |
| E | I was very surprised to see lead could protect radioactivity! |
| F | I was very happy and enjoyable to carry out various experiments. I would like to join such a class in the future once again. |

As shown in Table 1, all of them seemed to have strong and informative impressions about the contents. Strictly speaking, we should have compared the results without and with the Metaverse part. We could have carried out the same hands-on activity without the virtual class. However, they enjoyed the virtual class on Second Life very much obviously. That was the first and foremost strong overall impression after the project. As well as the questionnaire described below, their cheerful smiles indicated and supported very clearly that our impression was absolutely true. From the viewpoint of original STEM education policy, it obviously means the success of the project. We could achieve the goal to assure them that we should not be afraid and scared about radioactivity emotionally, but to make them realize that radioactivity should have been analyzed and considered technically and scientifically. And finally, the mixture and blending of the lecture, lead and guidance in virtual Metaverse and the hands-on experiments in STEM education could be effective, using Metaverse and the virtual system as one of the components.

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## References

[1] Bybee, R. W. What is STEM Education? *Science* 2010; **329** (5995): 996–996.
[2] Glass, C., & Minnotte, K. L. Recruiting and hiring women in STEM fields. *Journal of Diversity in Higher Education* 2010;3(4), 218–229.
[3] Smart, J.M., Cascio, J. and Paffendorf, J. *Metaverse Roadmap Overview* 2007; Accelerated Studies Foundation.
[4] Barry, D.M., Kanematsu, H., Fukumura, Y., Ogawa, N., Okuda, A., Taguchi, R., and Nagai, H., International Comparison for Problem Based Learning in Metaverse. *The ICEE and ICEER 2009 Korea (International Conference on Engineering Education and Research),* 2009; **1**: p. 60-66.
[5] Barry, D. M., Kanematsu, H., and Fukumura, Y., Problem Based Learning in Metaverse. *ERIC (Education Resource Information Center) Paper,* 2010;**ED512315**.
[6] Kanematsu, H., Fukumura, Y., Barry, D. M., Sohn, S. Y., and Taguchi, R., Multilingual Discussion in Metaverse among Students from the USA, Korea and Japan, in *KES 2010*; Springer Verlag: Cardiff, England, United Kingdom. p. 200-209.
[7] Kanematsu, H., Kobayashi, T., Ogawa, N., Fukumura, Y., Barry, D. M., and Nagai, H. Nuclear Energy Safety Project in Metaverse, in *Intelligent Interactive Multimedia: Systems & Services*, T. Watanabe, Editor 2012; p. 411-418. Springer-Verlag Berlin Heidelberg: Gifu, Japan.
[8] Barry, D. M., Kanematsu, H., Fukumura, Y., Kobayashi, T, Ogawa, N., and Nagai, H., Problem- Based Learning Activities in Second Life. *International Journal of Modern Education Forum (IJMEF),* 2014; **3**(1): p. 7-12.