Participatory Event Type MONO-ZUKURI Education Effectiveness for Future Creativity

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***Abstract*—Automobile mechanics, who are automotive engineers, have important responsibilities to maintain vehicle safety as "the family doctor of the car." It is necessary for automobile mechanics to acquire a national qualification for second-class automobile mechanics. By remarkable changes in vehicle progress and working environments in the recent years, automobile mechanics must acquire not only maintenance skills but also "skills for troubleshooting," "ability to overview a whole vehicle," and "communication skills." It is desirable to acquire those abilities during one's college days, but it is difficult to learn them using a traditional lecture style. "Participatory event type MONO-ZUKURI education," a project-based active learning process, is effective for acquiring all those capabilities together. As described herein, the authors describe educational practice of "the participatory event type MONO-ZUKURI education in Hokkaido" and its effectiveness.**

Keywords—automobile mechanics; participatory event type MONO-ZUKURI education; project-based active learning

I. INTRODUCTION

Students specializing in science or engineering must learn much knowledge and many skills for each area of expertise during a short period at a university. Therefore, high-expertise lectures and experiments are usually taught as school-style lectures. For example, in a junior college aiming at acquiring national qualifications of automotive mechanics, the curriculum is divided into "liberal arts subjects" and "expertise education subjects." Liberal arts subjects are usually taught with school-style lectures. However, "expertise education subjects" are roughly classified into "lecture to memorize the expert knowledge of automobiles" particularly addressing remembering the names and mechanisms of automobile parts and "experimental practice to the deeper understanding of what you learned from lectures." Although experimental practices are not school-style lectures, experiments have already shown the story and the conclusion. Students merely study them according to a lecture plan. Therefore, students who spend two years in such a curriculum course cannot acquire a general-purpose capability, which is an important feature of university education: "how to solve problems where the answer is not corresponding to one that has already been studied." Furthermore, recruiters request that students must acquire communication skills, problem finding ability, and problem-solving skills while in college. Responding to a student's ability development and corporate needs, it is indispensable for faculty members to introduce active learning for expertise education subjects in the college. Thinking "What is active learning for an ideal automotive engineer?" is regarded as "to make a vehicle." Through this activity, students must be able to acquire an "ability to overview the entire vehicle." This ability might be related to knowledge and experience of the automobile; it then lead students to acquire "skill of troubleshooting" and "creativity related to the automobile in the future." Of course, this activity also helps students to acquire communication skills.

A representative activity to create a vehicle in automotive engineering area is the "Student Formula Japan" competition held every year by the Japan Society of Automotive Engineers Association (JSAE). For Student Formula Japan, students manage virtual enterprises that manufacture and sell formula machines. The JSAE hope is to develop student capabilities. Then it is expected that students can become immediately useful as employees at a vehicle company. The participating team creates a student formula machine as presented in Fig. 1. The regulations for the safety of machines are severe, but are free in areas other than safety. The authors do not encounter the same machine as others. Each machine appears as a product of student creativity. In this way, the Student Formula efforts entail thinking as practical active learning. However, participating in the Student Formula Japan demands continuous effort for at least two years and the overcoming of many difficulties, for example, the understanding of regulations in English. Most participants are graduate students and university students from high-level universities, and they can. However, it may be difficult for junior college students and technical college students who majored in automotive

Fig. 1. Student Formula machine.

maintenance departments to overcome many difficulties because they are less academically inclined. The author's college participated in the 2011 Student Formula Japan for the first time as a junior college and was awarded "the first place of fuel economy award." Iwama and others reported the activity as useful for satisfying students' professionalism [1–3]. Nevertheless, it was difficult to participate the competition continuously because of the bottlenecks imposed by the school's short enrollment period and the students' academic ability.

The "Hokkaido Handmade Eco Car Contest" is one event of the Sapporo Motor Show. The contest is also a "participatory event type MONO-ZUKURI education" for high school students and college students in Hokkaido. This contest has lower participation hurdles than Student Formula Japan. Moreover, it is a great pleasure for students to display their machines along with vehicles presented by many automobile manufacturers.

For this study, the authors describe the "Hokkaido Handmade Eco Car Contest" in detail, and consider the effectiveness as the educational practice of "participatory event type MONO-ZUKURI education."

The authors assume that "MONOZUKURI" means creative design and manufacturing. "Participatory event type MONO-ZUKURI education" is defined as follows in JSAE homepage [4]. Students can actually create an object by themselves, which enables them to deepen their understanding of technology, cultivate their practical abilities and strive enthusiastically to achieve higher levels of accomplishment. The competition intends to aim at nurturing engineers who are rich in originality through an environment of object creation, in which they can learn the essence of object creation and the processes this entails, as well as experiencing team activities, and the difficulty, interest and enjoyment of object creation.

Fig. 2. Flyer of "Hokkaido Handmade Eco Car Contest".

II. Hokkaido Handmade Eco Car Contest

In Hokkaido, before the Sapporo Motor Show, the "Hokkaido Handmade Eco Car Contest" was held on October 9 and 10, 2009 as presented in Fig. 2 [5]. It was aimed at promoting momentum for holding the Sapporo Motor Show with public and private partnerships. In this contest, the organizer expects unique ideas and creative ideas of young students through the production of "handcrafted eco cars considering the regional nature of Hokkaido." Students reaffirm the "fun of MONO-ZUKURI" and apply their ingenuity to improving their technical capabilities. The event is also aimed at human resource development.

The basic eco-car production concepts are the following:

- Produce a vehicle powered by low environmental impact energy.
- Include ideas that take regional characteristics into account to the greatest extent possible.

There are almost no restrictions other than satisfying the fundamental performance as a car such as "run, turn, stop" and "machine size" limited by transportation and the size of the exhibition venue. The contest was completed with the participation of many students. All exhibited machines are original, exhibiting the student creativity. Figure 3 portrays two handmade eco-cars with the high evaluation. The picture on the left is the work of Asahikawa-Jitsugyo High School. The Asahiyama Zoo in Asahikawa is very famous, which has the exciting attraction of the penguin march. Students created the machine imitating a penguin and named "Escape Penguin." The picture on the right is a work of Hokkaido Kitami Technical High School. Kitami is one of the highest sunshine rates area in Japan, therefore the machine is covered with solar power generation panels. Brown objects in the middle are onion, which is one of the specialties of Kitami, it can be put in and out with button operation.

Subsequently, the "Hokkaido handmade eco car contest" was handed over as one exhibit of the Hokkaido Booth at the Sapporo Motor Show. Participating teams receive the

Fig. 3. Portrays two handmade eco-cars with the high evaluation.

guidance and cooperate with teachers and local companies. Then they create handmade eco-cars with free creativity.

III. Production of Exhibited Vehicles for Sapporo Motor Show 2014

It is fundamentally important to decide on the design in making a machine. After investigating existing cars, students assume that a vehicle that can travel comfortably in Hokkaido is a four-wheel drive car that can travel safely in the winter, with a warm vehicle passenger compartment. After choosing technical requirements, students set out the concept of "All Season Community Vehicle – a car for everyone."

Next, in accordance with the requirements described above, the main parts were defined as follows.

- Students made a light and robust pipe frame while emphasizing ease of frame making. Additionally, a roof was provided so that the driver can drive comfortably on a snowy road.
- There was the battery inside of the vehicle and styrofoam for high heat insulation because the battery generates heat during charging–discharging energy without a particular heating device.
- The machine weight distribution can be optimized using four in-wheel motors. The transmission efficiency is also improved. Furthermore, because of the high degree of freedom of suspension design, the interior of the passenger compartment can be wide and efficient.

In this way, students themselves thought about the most important designs in "MONO-ZUKURI." Thereby, they gained the "ability to overlook the vehicle" and also experienced "creativity in automobiles."

Regarding MONO-ZUKURI, because students were enrolled in a junior college for automobile mechanics, technology and skills were sufficient. However, schedule delays often occurred. They spent much time working on the machine every night and on weekends, but it was clear that it

Fig. 4. Exhibited vehicle for Sapporo Motor Show 2014.

was not going to be ready in time for the date to make the body of the "bear" using FRP. In this difficult situation, the student decided to give up fabrication with the FRP and to cover the vehicle with a furry cloth. By virtue of this design change, the machine was completed in time as portrayed in Fig. 4. In the contest, not only because of its high technical evaluation but also because of its "cute" impression, it received the Governor Encouragement Prize. Of course, the students were delighted with the results, forgetting the hard work necessary during its production.

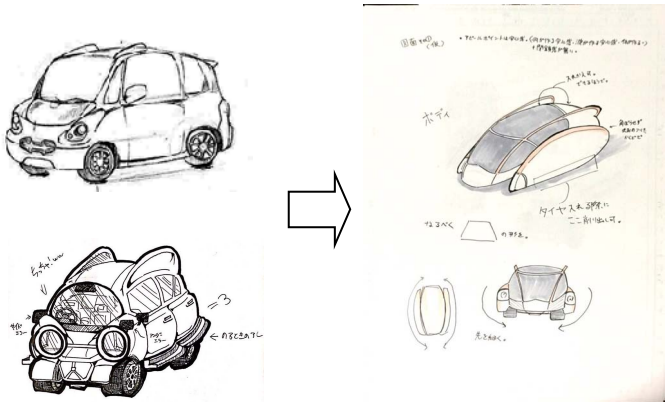
Questionnaire research, which is "Points of difficulty on student guidance at the time of machine making," was conducted among faculty members who instructed the production directly. The authors obtained the following answers.

> Because the time of activity was outside of lecture hours, students sometimes worked until midnight. Therefore, I carefully checked the students' health care, prevention of injuries during work caused by fatigue and drowsiness, etc. Furthermore, students said that they want to produce a high-performance vehicle for winning the best award. At the design stage, I facilitated to set up a proper target that the student can realize and achieve. Based on past experience, it did not go well whether the goal was too high or too low. The best mode of setting a proper target is slightly higher, but students must compromise because of various accidents that occurred during production. I sometimes had a hard time calming the dissatisfaction that occurred in realizing the design.

IV. Production of Exhibited Vehicles for Sapporo Motor Show 2016

The authors announced the contents to the students. More than 20 students, including not only the students of the junior college but also the students of other departments of the Hokkaido University of Science, started activities with the academic advisors.

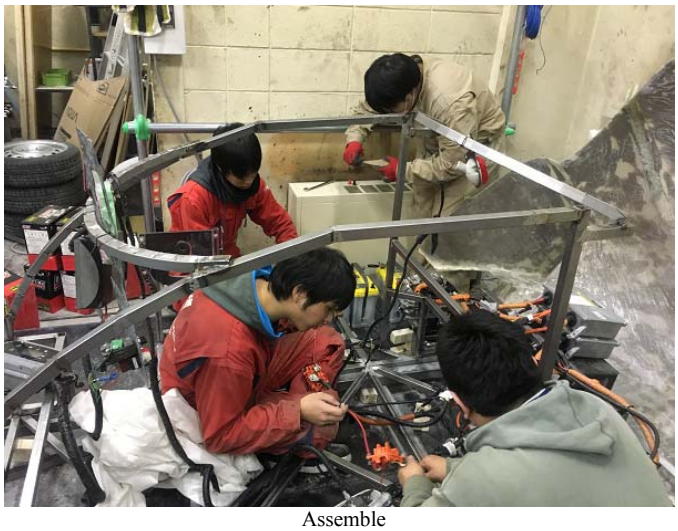
The power system of this machine applied in-wheel motors used in the prior event. It was specialized to follow the machine design with the production theme "Hokkaido-like eco-car for women." The machine was designed by a student of the Department of media design of the Hokkaido University of Science as presented in Fig. 5.



Ideas Fixed design

Fig. 5. Design thinking.

FRP resin



Assemble

Fig. 6. Snapshots of machine production.

The design took a long time until completion. Therefore, the machine production time was necessarily shortened. Students were compelled to work into the night every day. For the vehicle body, FRP resin was laminated on the male mold as shown in the upper of Fig. 6. Then the body was manufactured. Electrical parts and wiring were attached to the chassis as shown in the lower of Fig. 6. By virtue of the students' hard work in this challenging situation, the machine was completed in time.

Some students' ingenuity was invaluable to create features of the machine. They were color coordination based on pink and white with awareness of 'Women' as the theme this time, with creative design with curviness, a chassis mechanism, etc. The machine attracted visitors to the Sapporo Motor Show 2016. It won the Grand Prix, as portrayed in Fig. 7.

When the students looked back on their achievements calmly, the authors conducted a questionnaire survey of five of the junior college students who served in leading roles. Four gave responses. The students' answers are shown below.

Question 1: What is satisfying about the HUS01 production?

<Answer 1>

Of course, it was a pleasure when I completed it. Because there were ordinary lectures every day, my activity was involved from evening to midnight. It was too difficult for physical fitness. Furthermore, to make it easier to create machines, the club room was modified. I resembled a carpenter and acquired techniques that I never learned in the automobile department. I assume that I received a little about knowledge and technology that I can use in my future life.

<Answer 2>

What I am satisfied with working on production this time is that I was able to get an outstanding result. From the beginning, I assumed that I would achieve some result. I ended up winning the Grand Prix at the contest: the most memorable event in my college life. Even though I usually learned air suspension without seeing real objects, I cannot understand the air suspension mechanism. Through this experience, I know it because a teacher explained it while assembling actual air suspension.

<Answer 3>

I felt it a rewarding experience to be able to make moving vehicles from the beginning. Body making using FRP resin which cannot be learned in the lecture became most impressive. Skills needed to bend and cut the metal plate were improved. I was glad that many visitors looked at our machine at the Sapporo Motor Show 2016. It was also delightful that the university picked up our activities.

<Answer 4>

Despite being a college where students learned automobile maintenance, we had a chance to produce a vehicle. I am delighted that I was able to experience the design and assembly of a vehicle as well as creating real cars. Furthermore, I was able to learn many things that I cannot learn from lectures. I assume that it would be useful somewhere in the future. Before I enrolled in this college, I hoped and desired to improve myself. I think that my

desire might come true. Furthermore, I am happy that I was able to work with teachers so that I could make the machine much better than by working with students only.

Based on these results, the authors assume that the students were delighted with the experiences to make the machine from the beginning and with the Grand Prix.

Question 2: What frustrated you about making HUS01?

<Answer 1>

The production period was short; I could not work with any margin. Because of the university relocation, it was difficult to go and come between two workplaces. Because I was unable to communicate well with both the people who could not come every day and the people who came every day, I often did not know what to do.

<Answer 2>

What I thought dissatisfying when I was involved in the production of HUS01 is that the production period from the theme announcement to the contest was too short.

Fig. 7. Exhibited vehicle (HUS01) for Sapporo Motor Show 2016.

<Answer 3>

There were few days I was able to work. If I had started earlier, I think that I could have met many challenges.

The period from the beginning of the activity to the contest was very short: almost three months. Therefore, dissatisfaction was concentrated on the fact that students were not able to prepare sufficiently. However, it seems that there was no dissatisfaction for this production work itself.

TABLE I. QUESTION 3: HAVE YOU DEMONSTRATED YOUR CREATIVITY IN MAKING HUS 01? (PLEASE SELECT ONE)

I was able to demonstrate it very much.	0
I was able to demonstrate it reasonably.	2
Neither.	1
I was able to only demonstrate it slightly.	1
I was unable to demonstrate it at all.	0

Because the machine was made from the beginning, students were easy to incorporate their mode of thinking to a certain degree. A mutual compromise for producing the machine was also required. Not all students demonstrated creativity.

TABLE II. QUESTION 4: WOULD YOU RECOMMEND JOINING THE JUNIORS IF "MONO-ZUKURI" EVENT LIKE HUS01 PRODUCTION IS TO BE HELD IN THE FUTURE? (PLEASE SELECT ONE)

Strongly No	0
No	0
Neutral	0
Yes	2
Strongly Yes	2

This question is representative as a summary of students' satisfaction. Overall results show that the students generally enjoyed this activity and that they were satisfied with it.

Questionnaire research was also conducted among faculty members who directly instructed the production on "Points of difficulty on student guidance at the time of machine making." The authors obtained the following responses.

The machine was made across several departments. I was trying to take much time to incorporate the maximum opinions of all students and to complete the vehicle by the due date. For example, regarding the machine design, I facilitated mutually discussion among students about the production theme set by the organizer and to design the machine that can be produced and which can run. First, it became a design in which the steering wheel could not be handled because of differences in the recognition of cars. The machine did not fulfill "run, turn and stop" which is the fundamental performance of a car. Therefore I instructed students to confirm the problems and then improve them. As a result, machine design took a lot of time. Therefore, the time spent on the production became short. Students in charge of the production took a hard time, but students who are not familiar with the car can create unique machines in the future.

V. DISCUSSION

Although "Hokkaido Handmade Eco Car Contest" has less difficulty than Student Formula Japan, the questionnaire results demonstrated the possibility of obtaining great satisfaction if the machine is completed with the students' best efforts. Therefore, the "Hokkaido Handmade Eco Car Contest" the is sufficient as practice of "participatory event type MONO-ZUKURI education." Depending on student individuals, they can acquire "the ability to overlook the whole car" and experience "creativity related to automobiles" to a certain degree. Regarding "creativity related to automobiles," results clarified that the "deadline effect" is an important factor to demonstrate higher levels of creativity. Moreover, it seemed that a difficult due date comes to enhance creativity. The possibility that it will not be completed in time for the event also rises simultaneously. Faculty members must balance the "educational effect of MONO-ZUKURI," "possible disqualification" and "the state of health and satisfaction of the students."

Students participated in the event and achieved satisfying results. Their efforts became worthwhile. No difficulty exists if it is the short term event. However, as the event continues to the next generation, even students who are interested in the contents of the activity or the results of the previous generation assume that "The seniors are amazing. However, we cannot make such an awesome achievement." Therefore, they do not participate in activities. Consequently, the experience cannot be passed down. For that reason, faculty members must return to the start. Furthermore, this tendency appears more strongly as the obtained result improves. The authors assume that "participatory event type MONO-ZUKURI education" might increase educational effects through multiple generations. When the activity's difficulty is too high and/or the result is too valuable, the educational effect becomes remarkable. Conversely, it is proportionately more difficult to continue such a high level of activity. In contrast, the motivation of students does not rise. The educational effect decreases when the activity's difficulty is low and/or the result is not good. Our experience clarifies that a tradeoff relation exists.

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