DESIGN AND IMPLEMENTATION OF A HYDROGEN ENERGY ENGINEER EDUCATION PROGRAM UTILIZING FIELDWORK IN MIE PREFECTURE

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In Japan, the world's first national strategy for hydrogen, the Basic Hydrogen Strategy, was formulated in 2017, and research and development efforts have been undertaken to realize a hydrogen society. However, challenges such as insufficient hydrogen infrastructure, the high cost of hydrogen fuel, and a shortage of professionals specialized in high-pressure gas safety remain significant obstacles. To address these challenges, fostering public understanding of a hydrogen society is essential. While awareness of hydrogen has been increasing, interest in hydrogen as a future energy source remains low.

This study implements a hydrogen education program for second-year KOSEN students to foster the advancement of social infrastructure for a hydrogen-based society. The program includes specialized lectures on hydrogen-related topics delivered by KOSEN faculty members, along with site visits to observe local initiatives promoting carbon neutrality and hydrogen energy. Building on this knowledge, students create educational materials for elementary school students and conduct outreach lectures to enhance public understanding of hydrogen energy.

First, fieldwork was conducted at the Suzuka Circuit to explore carbon neutrality initiatives. Formula 1 has announced a plan to achieve net-zero carbon emissions by 2030, and various efforts are underway to realize this goal. During their visit, the students toured the Suzuka Circuit facilities and deepened their understanding of carbon neutrality through direct discussions with engineers. Next, they conducted fieldwork at a mobile hydrogen station, where they learned about the challenges of operating a hydrogen station, the human resources needed to promote a hydrogen society, and the importance of encouraging hydrogen utilization. Additionally, they attended specialized lectures on hydrogen technology given by a faculty member engaged in hydrogen research at the National Institute of Technology. Through these lectures, students gained insights into the challenges associated with "producing," "transporting," and "storing" hydrogen, the necessity of building a supply chain for a hydrogen society, and the technological research challenges related to hydrogen infrastructure.

Based on the knowledge they learned, the students deepened their understanding of hydrogen energy by giving delivery classes. The students were provided with opportunities to deepen their understanding of hydrogen energy through both instruction and hands-on experience, including explanations of basic concepts of hydrogen energy and a hands-on class using a hydrogen rocket learning kit.

Keywords: Realization of hydrogen society, STEAM education, Practical education, Engineering education, PBL

Introduction

Hydrogen has been receiving increasing attention as an environmentally friendly energy source. Since hydrogen does not emit CO_2 during combustion, it does not contribute to global warming. In 2017, the Japanese government formulated the world's first national strategy, the Basic Hydrogen Strategy, to promote the utilization of hydrogen. This strategy was revised in 2023, setting a target of introducing 12 million tons of hydrogen annually by 2040.

However, progress toward establishing a hydrogen-based society has been hindered by the high costs associated with hydrogen infrastructure. In order to support governmental policies and corporate initiatives aimed at promoting hydrogen utilization, it is essential to enhance public understanding of hydrogen energy. Moreover, the successful realization of a hydrogen society depends on the widespread public acceptance of hydrogen as a viable energy source. From this standpoint, the importance of educational programs that provide experiential learning opportunities and foster a deeper understanding of hydrogen energy has been increasingly emphasized. Concurrently, Japan's education sector has been actively promoting Project-Based Learning (PBL),

which encourages students to engage in solving real-world social issues through interdisciplinary approaches.

In this educational research, a project was implemented within the second-year course Design Fundamentals at the National Institute of Technology, Suzuka College in which three students were assigned to develop hydrogen energy learning materials intended for use at local community events.

Program Design and Implementation

This study was carried out through the following six steps:

1. Students engaged in fieldwork to learn about efforts toward realizing a hydrogen-based society.
2. Students attended a lecture delivered by a subject-matter expert.
3. Students gave a poster presentation on what they had learned.
4. Students developed educational materials to facilitate learning about hydrogen energy.
5. Students organized a public workshop.
6. A presentation venue was arranged to exhibit the outcomes of their activities.

1. Students learned about efforts toward realizing a hydrogen society through fieldwork.

The objective of the fieldwork was to help students understand the functioning of hydrogen energy systems and the broader societal initiatives aimed at addressing global warming, including carbon neutrality. This experience served to enhance their motivation for the project and to provide them with foundational knowledge.

1.1 Fieldwork at Suzuka Circuit

In the motorsports industry, environmental sustainability has become an urgent concern, and automakers are actively working toward carbon neutrality, including by entering vehicles equipped with hydrogen-powered engines. On September 28, 2024, fieldwork was conducted at Suzuka Circuit as shown in Figure 1. A wide range of vehicles participated in the Super Taikyu race held at the venue, from those with conventional engines to those using carbon-free powertrains. Learning about each company's initiatives in this competitive and experimental racing environment provided students with a valuable opportunity to gain deeper technological insight and develop the mindset needed to forge their own paths toward the future.

Figure 1. Students observing carbon-neutral initiatives during a field visit to the Suzuka Circuit.

First, the students visited the racing gallery at Suzuka Circuit, where they observed various machines and engines and learned about the technological evolution over time.

Next, they toured the Formula 1 pit area to view the vehicles participating in the race and received explanations from engineers regarding the objectives and mechanics of the race, as well as the challenges involved in enhancing the environmental performance of race cars.

Finally, they engaged in a discussion with a former Suzuka Circuit official and learned about ongoing initiatives aimed at achieving carbon neutrality in Formula 1 racing.

1.2 Observation of a Mobile Hydrogen Station

On November 5, 2024, the students visited a mobile hydrogen station. One of the key challenges in realizing a hydrogen-based society is the slow progress in the deployment of hydrogen infrastructure. Through this fieldwork, the students gained insights into the technical and societal issues associated with building such infrastructure. It is estimated that between 1,000 and 2,000 hydrogen refueling stations will be required nationwide to support the realization of a full-scale hydrogen society. At present, however, only about 30 mobile hydrogen stations exist across Japan, and these are expected to be gradually replaced by permanent facilities in the coming years.

Figure 2 shows the students' visit to the Mobile Hydrogen Station. During the visit, the station staff explained that there are legal regulations governing the allowable amount of hydrogen storage, that the service life of compressed hydrogen fuel containers used in fuel cell vehicles is 15 years, and that it costs approximately 15 million yen to dispose of two such containers. Through this experience, the students gained a clearer understanding of the practical challenges associated with hydrogen infrastructure, which helped them develop a greater awareness of the specific issues that must be addressed in realizing a hydrogen society.

Figure 2. Fieldwork visit to a mobile hydrogen station.

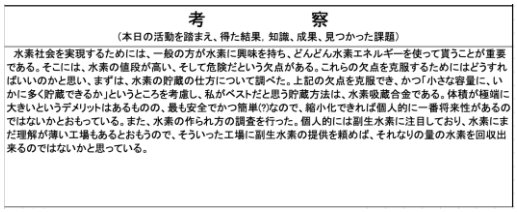
2. Students Attended a Lecture by an Expert

On October 11, 2024, a specialized lecture on hydrogen energy was delivered by Associate Professor Nishiguchi from the National Institute of Technology, Sasebo College. The lecture covered technologies related to hydrogen production and utilization, as well as current technical challenges in the field.

Figure 3 shows the students attending the lecture. The students learned about various methods of hydrogen storage, including metal hydrides, compressed hydrogen gas, ammonia, liquid hydrogen, and toluene. They also gained deeper insights into hydrogen embrittlement, which is Associate Professor Nishiguchi's area of expertise. In the domain of hydrogen production, the lecture addressed multiple sources such as renewable energy, by-product hydrogen, and fossil fuels. With respect to hydrogen applications, students studied its use in fuel cell vehicles and hydrogen engines, as well as its potential role as an emergency power source. In addition, advanced topics were discussed, including the importance of financing and other key elements required to build a hydrogen supply chain.

Figure 4 shows a student's project report. As part of this educational program, students submitted short reports after each session. These reports served both as a means for students to consolidate their understanding and as a tool for instructors to track their learning progress. The student developed a strong interest in metal hydrides and explored the possibility that this method could be one of the most effective approaches for hydrogen storage. In the report, the student examined both the advantages and potential challenges of the method, with a particular focus on its future applicability.

Figure 3. Students attending the lecture delivered by Associate Professor Nishiguchi.



考　　察

（本日の活動を踏まえ、得た結果、知識、成果、見つかった課題）

水素社会を実現するためには、一般の方が水素に興味を持ち、どんどん水素エネルギーを使って貰うことが重要である。そこには、水素の値段が高い、そして危険だという欠点がある。これらの欠点を克服するためにはどうすればいいのかと思い、まずは、水素の貯蔵の仕方について調べた。上記の欠点を克服でき、かつ「小さな容量に、いかに多く貯蔵できるか」というところを考慮し、私がベストだと思う貯蔵方法は、水素吸蔵合金である。体積が極端に大きいというデメリットはあるものの、最も安全でかつ簡単(?)なので、縮小化できれば個人的に一番将来性があるのではないかとおもっている。また、水素の作られ方の調査を行った。個人的には副生水素に注目しており、水素にまだ理解が薄い工場もあるとおもうので、そういった工場に副生水素の提供を頼めば、それなりの量の水素を回収出来るのではないかと思っている。

Figure 4. A report written by a student as part of the learning project.

3. Students Presented Their Learning in a Poster Session

On November 1, 2024, the students gave a poster presentation at the KOSEN Hydrogen Forum 2024 held in Kurume. The presentation was based on the content covered during the learning activities conducted in October 2024. In preparing the presentation materials, the students reflected on their prior learning and summarized the key points. Figure 5 shows a portion of the poster they created. The presentation process provided a valuable opportunity for the students to organize and consolidate their understanding of the topics studied.

Figure 5. A portion of the poster created by the students.

4. Students Created Teaching Materials to Help Others Learn About Hydrogen Energy

As a culmination of their learning, the students began developing educational materials on hydrogen energy targeted at elementary school students. Figure 6 shows a slide created by the students to explain the differences between fossil fuels and hydrogen fuel.

They considered how to explain the principles of hydrogen-based power generation, the reasons why hydrogen energy is attracting attention, and how to effectively demonstrate its real-world applications.

Figure 7 shows an instruction manual created by the students for operating this kit. Subsequently, the students focused on a commercially available hydrogen rocket learning kit. This kit enables hydrogen generation using a hand-powered generator and launches a small rocket by igniting the produced hydrogen.

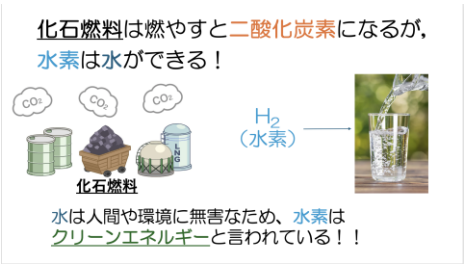


Figure 6. A slide created by the students to illustrate the differences between fossil fuels and hydrogen fuel.

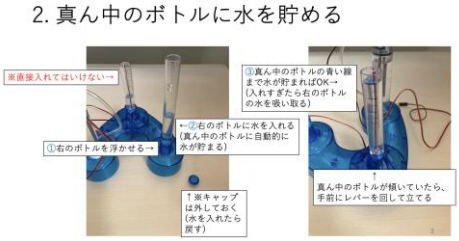


Figure 7. An instruction manual created by the students for operating a hydrogen rocket learning kit.

5. Students Conducted a Public Workshop

In March 2025, the students conducted a public workshop for elementary school students using the educational materials they had developed. The target participants were sixth-grade students, and the college students assumed the role of instructors. Figure 8 shows a poster created to promote the workshop. During the session, the students explained the utilization of hydrogen energy and carried out a hands-on

demonstration by launching a hydrogen-powered rocket as a tangible example of its application.

Figure 9 shows elementary school students engaging with the hydrogen rocket activity. The participating students were able to enjoyably learn that hydrogen can be applied in practical ways.

Figure 8. A promotional poster created to advertise the workshop.

Figure 9. Elementary school students engaging with the hydrogen rocket activity.

6. A Presentation Venue Was Arranged to Exhibit the Outcomes of Their Activities

To broadly disseminate the outcomes of these student-led activities to the public, a presentation venue was organized. An exhibition booth utilizing hydrogen rockets as educational tools is scheduled to be featured at Super Formula Rd11–12 in Suzuka on November 11–12, 2025. The target audience is the general public, with the aim of raising awareness of and interest in hydrogen energy across a wide demographic. Figure 10 shows the announcement of the Suzuka Circuit event distributed to technical colleges across Japan.

Figure 10. A promotional announcement for the upcoming Suzuka Circuit event featuring the hydrogen energy outreach booth.

Results and Discussion

The program enhanced students' understanding of hydrogen energy through fieldwork, expert lectures, and hands-on activities. At the KOSEN Hydrogen Forum, students effectively presented key concepts such as hydrogen production and storage. In the public workshop, elementary school participants responded positively to the hydrogen rocket activity, indicating the materials were engaging and accessible. The scheduled exhibition at Super Formula further demonstrates the outreach potential of student-led initiatives.

While the educational kit effectively demonstrated the process of generating hydrogen from water and utilizing it as an energy source through combustion, it did not explore the conversion of hydrogen into electrical energy. In the future, to expand hydrogen education more broadly, it will be necessary to develop additional teaching materials that take into account cost and safety considerations.

Conclusions

This study implemented a PBL-based hydrogen education program that effectively integrated technical learning with community outreach. Through real-world activities, students not only deepened their understanding of hydrogen energy but also developed essential communication skills. The program was uniquely designed by aligning the social challenges of hydrogen energy and motorsports with the regional characteristics of Suzuka City in Mie Prefecture. Given that the development and utilization of hydrogen infrastructure remain limited on a national scale, there is a pressing need to cultivate an educational foundation that supports the widespread implementation of fieldwork-based learning. By capitalizing on the scale and collaborative network of KOSEN institutions and partnering with companies and local governments engaged in hydrogen-related initiatives across Japan, the fieldwork component of this program could be further expanded. Such efforts would enhance the program's transferability and promote its adoption in diverse educational contexts.

The results suggest that programs of this kind can play a vital role in fostering future engineers and raising public awareness of hydrogen energy on a broader scale.

Acknowledgements

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