Proposal of the SIR curriculum for Enhancing Students' Motivation to learn in Technology Education

Satoshi FUJIKAWA
Assoc. Prof., Graduate School of Education
Hokkaido University of Education, Asahikawa City, Hokkaido, Japan

Tadashi CHAKI
Kita Sougou Special Support Schools, Kyoto City, Japan

Shinichi HARADA
Assoc. Prof., Faculty of education
Kyoto University of Education, Kyoto City, Japan

Shigeki ANDO
Trustee & Vice-President
Kyoto University of Education, Kyoto City, Japan

Takemi MIZUKAMI
Prof., Graduate School of Education
Hokkaido University of Education, Asahikawa City, Hokkaido, Japan

Abstract- In this study, we propose the "selective inductive research curriculum" (hereinafter, "SIR curriculum") as a learning strategy to enhance students' learning motivation towards "technology of energy conversion" and practice this method in a classroom in junior high school. The SIR curriculum is a method where rather than a one-size-fits-all class in which every student studies the same content, students select theme of study tailored to their interest. The SIR curriculum was practiced on 30 third-grade students of X Junior High School, X City, Japan in 200X. The results of the questionnaire administered following the classes as well as the impressions of the students suggested that students enjoyed learning about technology of energy conversion in this curriculum and felt such knowledge would be useful in the future. It is suggested that the method is an effective way in which to enhance students' learning motivation and learning, even within a small period of time.

Keywords – SIR curriculum, Motivation to learn, Technology education, Technology of energy conversion

I. INTRODUCTION

Our present way of life has come about from the pursuit of a rich and convenient lifestyle. A large part of this is supported by products that utilize energy conversion such as electrical products. However, many products that utilize energy conversion consume a large quantity of the natural world's precious resources and have placed a significant burden on the natural environment. Our current rich lifestyle is made up at the expense of environmental destruction on a global scale. Many people live a comfortable life, taking the use of advanced technology such as electrical products for granted, without paying attention to these issues. However, in order to achieve both a comfortable lifestyle and sustainable society, we must understand both the pros and cons of advanced technology and develop the ability to evaluate technology and use it appropriately. Accordingly, it is extremely important that students, who are responsible for the future, acquire an interest in and fundamental knowledge and skills relating to the technology of energy conversion.

In compulsory education in Japan, technology education is provided in the "Technology and Home Economics" subject taught in junior high school. The "technology" covered in this subject includes the aforementioned "technology of energy conversion", for which students are required to acquire basic knowledge and skills., This knowledge must be a living knowledge learnt through interest rather than knowledge that has been embedded. Despite this, it is reported that more and more Japanese junior high school students "hate science" or are "becoming separated from science" and have decreased motivation to learn about "technology", particularly content related to "technology of energy conversion" (NIER, 2007)[1]. This study proposes the "selective inductive research curriculum" as a teaching method to increase students' motivation to learn about technology of energy conversion. This study also verifies the educational effect of the SIR curriculum through the impressions of students and the results of questionnaire surveys following classroom implementation.

II. Technology Education in Japanese Junior High Schools

A. *The Content of Technology Education –*

"Technology"-related learning content in Japanese junior high schools is made up of "technology of materials and their processing", "technology of energy conversion", "technology of nurturing living things", and "technology of information processing" (MEXT, 2008) [2]. Students are required to acquire basic and fundamental knowledge and skills related to each learning contents. The Project Method has been used for a long time in Japanese technology education. The Project Method is a teaching method advocated by Kilpatrick (1918) [3] with a focus on experiential and practical activities such as making things, etc. in which students solve problems through their own planning and practice. The new national curriculum guidelines published in 2008 in Japan also inherited the Project Method philosophy, requiring "the development of knowledge, skills and problem-solving ability through experiential and practical activities" (MEXT, 2008) [4]

B. *Changes in The Number of Classroom Hours –*

Presently, junior high school students receive 87.5 hours of classroom technology education over three years. According to a survey by Nakazono (2012) [5], the number of classroom hours devoted to technology education has declined with each revision of the national curriculum guidelines since 1958. The change in the number of technology education classroom hours is displayed in Table 1 below.

Table-1 Change in the number of technology classroom hours

Revision year	1958	1969	1977	1989	1998	2008
Compulsory education (h)	315	315	245	175	87.5	87.5
Elective education (h)	105	105	35	70	70	0

Based on a survey by Nakazono (2012)

Prior to 1977, subjects differed according to gender; boys studied technology and girls studied home economics. Even taking this into account, the decrease in technology education classroom hours has been significant. As the current technology education content, mentioned earlier, is more diverse than in the past, teachers are required to devise a method for students to learn this diverse content during limited classroom hours.

III. The Purpose and Position of This Study

The purpose of this study is to enhance students' motivation to learn about "technology of energy conversion". This is a difficult task to achieve through a one-size-fits-all lecture format class. Incorporating a wide variety of experimental learning and investigative learning tailored to the interest of students as well as lectures is considered effective in increasing students' motivation to learn. However, fitting such a variety of learning into the limited classroom hours is extremely difficult. Therefore, this study has developed the selective inductive research curriculum as an educational method to enhance the learning motivation of students and effectively incorporate a variety of learning over a short period of time.

This paragraph contains an overview of previous research on learning motivation to confirm the position of the present study. Learning motivation, in the field of cognitive psychology, is positioned within the framework of trying

to accomplish a goal ("achievement motive"). Achievement motive research expanded rapidly with McClelland et al (1959) [6] development of an achievement motive measurement method. Atkinson et al (1964, 1966) [7] [8] representation of the relationship between achievement motives and achievement acts, etc. also provided impetus for many achievement motive- related studies. Raynor (1969) [9] and Weiner et al (1971) [10] subsequently advanced achievement motive research. The concept of intrinsic motivation typified by Deci (1980) [11] and deCharms (1968) [12] and Bandura's (1977) [13] theory of Self-efficacy are also well known and have had a major impact on the study of learning motivation in Japanese education.

Next, let's review the studies on learning motivation in Japanese technology education. Ichihara et al (2011) [14] showed, from the analysis of questionnaire results, that support measures that consider the different cognitive styles of learners are important in stimulating learning motivation in technology-related subjects. Muramatsu et al (2009) [15] results indicated that an information sharing system utilizing CMS enhanced students' learning motivation. The development of many more teaching aids and production materials to enhance students' learning motivation such as Fujikawa et al (2011) [16] development of production materials using blue LEDs, Yoshida et al (2007) [17] development of PIC-utilizing solar power study teaching tools, and Yamamoto et al (2007) [18] development of teaching tools for the study of power generation by temperature difference, etc. has also been reported. The authors of this paper have not, however, come across educational practice utilizing a method similar to the present study in any studies on learning motivation in technology education. Accordingly, the investigational novelty of this study can be confirmed.

IV. Over View of The SIR curriculum

The SIR curriculum is a method where rather than a one-size-fits-all class in which every student studies the same content, students select theme of study tailored to their interest. Three types of selective theme of study (ABC) that can be prepared in a typical junior high school were adopted and are displayed in Table 2. The flow of the SIR curriculum is displayed in Fig.1. A layout of workroom is displayed Fig.2 and an image of selective group study is displayed Fig.3.

Table-2 Selective theme of study

	Theme of study
A	Energy conversion experiments study
B	Energy conversion investigative study
C	Robot study

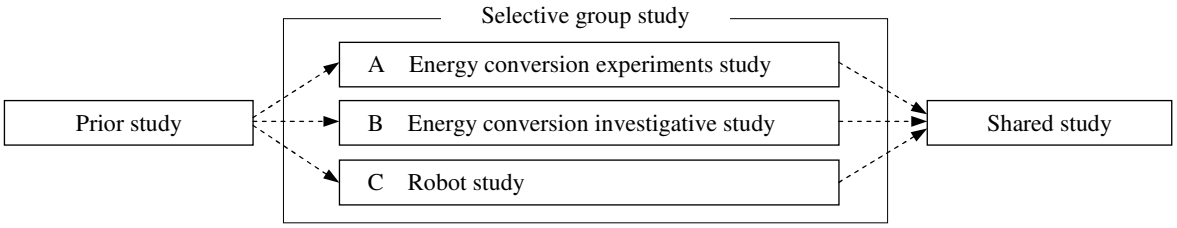

Fig.1. Flow of the SIR curriculum

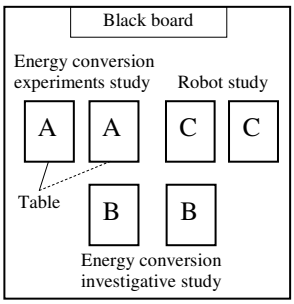

Fig.2. A layout of workroom

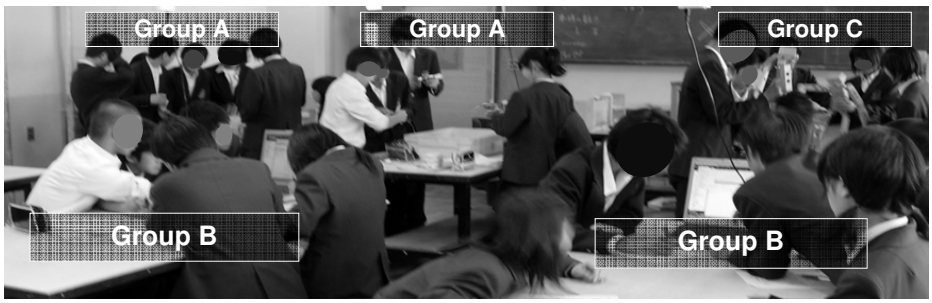

Fig.3. An image of selective group study

Let's look at the flow of the SIR curriculum. In "prior study", the teacher will explain the flow of the SIR curriculum and describe the selective theme of study (A-C). Students will then select theme (A-C) depending on their interests. At this time, there is the possibility of bias in the number of students assigned to each theme; however there has not been such bias to the extent that group study could not be realized in the author's experience so far. The number of students in each group may have to be adjusted if there is significant bias; however it is desirable to prioritize the desires of the students as much as possible. In "selective group study", students independently tackle their desired theme. Each study material for theme and worksheet indicating the how to study is placed on each group's table to assist students in studying independently. "Selective group study" is positioned as "group research" from which students will announce their learning outcomes later in "shared study". In "shared study", the "selective group study" groups are broken up and new "shared study" groups are formed. At this time, "shared study" groups should be arranged as best as possible to consist of even numbers of students from each "selective group study" group (ABC) (for example, a shared study group with six members should ideally be made up as follows: A, A, B, B, C, C). An image of shared study is displayed Fig.4. The members from each "selective group study" group then will then take turns sharing their research results with the other members of their "shared study group". Finally, each student will create their own research report which summarizes the content of all study material (ABC). An image of research reports is displayed Fig.5.

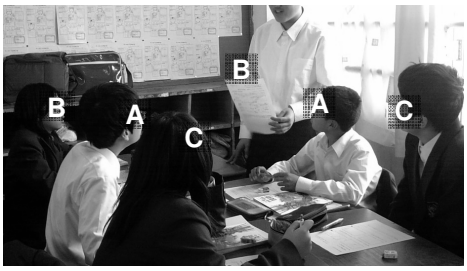

Fig.4. An image of shared study

Fig.5. An image of research reports

V. CLASSROOM PRACTICE

The SIR curriculum was practiced on 30 third-grade students of X Junior High School, X City, Japan in 200X. Each "selective group study" group engaged in self-study. As each group tackled different themes, classes for each "selective group study" group could not be done in unison. The teacher explained to the students how to proceed with study and allowed them to study for themselves rather than conveying knowledge and skills. To facilitate this, worksheets, materials, and sheets in which students could easily fill in their results and reflections, etc. were prepared in advance. The teacher kept an eye on each group and offered advice if necessary. One hour was devoted to "prior study", four hours to "selective group study", and four hours to "shared study" (including the creation of research reports). The selective group study content was as follows.

A. Energy conversion experiments study –

Six energy conversion experiments were prepared and are displayed in Table 3. Students select four of the six experiments displayed in Table 3 that they are interested in and independently perform each experiment for one hour.

Table-3 Energy conversion experiment content

	Content
1.	Hand-cranked generator experiment（Fig.6: An example of experiment）
2.	Stirling engine assembly and experiment
3.	Peltier element temperature difference power generation experiment
4.	Piezoelectric element experiment and product proposal
5.	Solar power experiment
6.	Fuel cell vehicle experiment

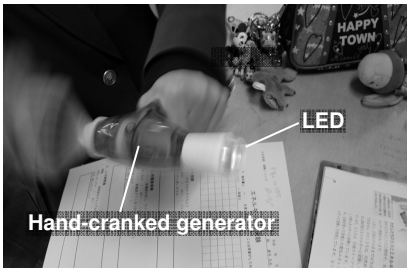

Fig.6. An example of experiments

As well as acquiring knowledge through these experiments, students

are made to consider things from the "technical" perspectives of "it can be applied to the manufacturing of products" and "it can be of use to our lifestyle". Students cooperate in groups to tackle the experiments and engage in discussion.

B. Energy conversion investigative study –

In the investigative study group, students form groups to examine and study past, present and future technologies and products with a focus on technology of energy conversion. Each group then creates their own portfolios and posters, etc. Computers equipped with multimedia encyclopedias and internet access are placed in the classroom (so it is set up like a technology room, etc.) to prepare an environment in which students can study. Energy conversion-related books and materials are also made available. The view of investigative study is displayed Fig.7 and the view of a students work (creating a poster) is displayed Fig.8. The important thing in group study is that all group members are involved in study and produce one deliverable upon completion of the study. If some students take the lead and produce deliverables on their own, it cannot be called group study. Therefore, the teacher must divide roles and provide precise instructions.

Fig.7. Investigative study

Fig.8. A students work (creating a poster)

C. Robot study –

In the robot study group, students learn about the basic elements of robot mechanisms using models and teaching materials. For example, they use a robot model to investigate the position of the center of gravity as the robot is walking on two legs. The photograph of robot model is displayed Fig.9. They also learn about motor and gear box mechanisms, etc., and assemble a simple moving robot using a motor, gear box and tires. A "robot contest" can also be held in which the simple moving robots compete in simple competitions such as pushing and moving a ping-pongs ball, etc.

Fig.9. Robot model

VI. Reaction of Students After Study

The questionnaire shown in Table 4 was given to students following classroom implementation of the SIR curriculum. In addition, students who finished the classes were asked to freely write their impressions of the classes. The results of the questionnaire after study shown in Table 4 are displayed in Table 5.

Table-4 Questionnaire after study

Content	
Q.1	Were the SIR curriculum fun?
Q.2	Did the SIR curriculum increase your interest in technology of energy conversion?
Q.3	Did you acquire knowledge of technology of energy conversion in the SIR curriculum classes?
Q.4	Do you think the SIR curriculum will help you in future life?

Table-5 Questionnaire results

		I think so very much.	If I had to say, I think so	If I had to say, I don't think so	I don't think so at all.
Q.1	number (%)	10 (33%)	15 (50%)	4 (13%)	1 (3%)
Q.2	number (%)	11 (37%)	12 (40%)	5 (17%)	2 (7%)
Q.3	number (%)	9 (30%)	14 (47%)	5 (17%)	2 (7%)
Q.4	number (%)	7 (23%)	13 (43%)	6 (20%)	4 (13%)

N=30

The questionnaire results displayed in Table 5 indicate that many students enjoyed the SIR curriculum classes and gained further interest in technology of energy conversion. The results also show that many students acquired knowledge related to technology of energy conversion and believed that such knowledge would be useful in the future.

Next, the questionnaire shown in Table 6 was given to students before and after classroom implementation of the SIR curriculum. Each contents of the questionnaire were inquired students to choose between "I think so very much" (4 points), "If I had to say, I think so" (3 points), "If I had to say, I don't think so" (2 points), "I don't think so at all" (1 point), and their responses were scored out of a maximum of 4 points based on above allotment. Outcomes of them (*Mean*, *SD, t value*) are shown in Table.7.

Table-6 Questionnaire before and after study

Content	
Q.I	Are you interested in technology class?
Q.II	Are you interested in technology of energy conversion?

Table-7 Questionnaire content

	Before		After		*t value*
	Mean	*SD*	*Mean*	*SD*	
Q.I	3.07	0.81	3.33	0.65	2.08^{*}
Q.II	2.60	0.95	3.13	0.72	3.93^{**}

N=30, * $p<0.5$, ** $p<0.1$

Outcomes of the questionnaires on both Q.1 and Q.2 show that there are significant differences between means before and after classroom implementation of the SIR curriculum. Based on the above observation, it was inferred that SIR curriculum enhanced leaning motivation toward technology of energy conversion, as well as technology class. Moreover, upon review of students report after classroom implementation of the SIR curriculum, many students completing the classes expressed opinions indicating a high interest in the classes and subject content such as "I was glad I could choose what I wanted to study", "it is fun to study when working together with others" and "technology of energy conversion was difficult for me before, but it feels more familiar after finishing the classes", etc.

On account of above observations concerning reaction of students after study, it was inferred that SIR curriculum enhanced learning motivation toward technology of energy conversion.

VII. CONCLUSION

In this study, we proposed the "selective inductive research curriculum (SIR curriculum)" as a learning strategy to increase students' learning motivation towards "technology of energy conversion" and practiced this SIR curriculum in a classroom. The results of the questionnaire administered following the classes as well as the impressions of the students suggested that students enjoyed learning about technology of energy conversion in SIR curriculum classes and felt such knowledge would be useful in the future. It is suggested that the SIR curriculum is an effective way in which to enhance students' learning motivation and learning, even within a small period of time. However, the outcome has not enough evidence because the outcome was only one practice of one school. It is necessary to carry out practical activities utilizing the SIR curriculum in various works and undertake detailed verification based on data in order to further clarify these possibilities. We would like to practice SIR curriculum covering various learning contents and explore further possibilities of the SIR curriculum in the future.

ACKNOWLEDGMENT

The authors would like to thank Dr. Fumitaro Sekine of Kyoto University of Education for his matchless technical competence and his unfailing loving assistance. Thanks also Mr. Toshihide Enomoto, who is a supervisor of Kyoto city Board of Education, for his great instruction in technology education. In addition, we wish to thank Mr. Yosinobu Hatanaka of Kyoto City Board of Education, who is a former principal of Kyoto municipal Katsuragawa junior high school, for his continuous support. Finally, the authors are grateful to teachers of Kyoto city for assistance with educational practices.

REFERENCES

[1] NIER. (2007). Findings of the Investigation "Technology & Home economics" Concerning Specific Subject (p.48), NIER: Curriculum Research Center.
[2] MEXT. (2008). Course of Study for Junior High Schools (p.18), National Printing Bureau.
[3] Kilpatrick, W.H. (1918). The Project Method, Teachers College Record, 19(4), 319-335.
[4] MEXT. (2008). Course of Study Commentary, Technology and Home Economics (pp.11-13), Kyoiku-tosho Pub Co., Ltd.
[5] Nakazono, M. (2012). Research Report of Daiichi Institute of Technology, 24, 63-74.
[6] McClelland, D.C., Atkibson, J., Clark, R. A., & Lowell, E. L. (1953). The achievement motive, New York: Appleton-Century-Crofts.
[7] Atkinson, J.W. （1964）. An introduction to motivation, Princeton, New Jersey: Van Nostrand.
[8] Atkinson, J.W. & Feather, N.T. （1966） A theory of achievement motivation, New York: Wiley.
[9] Raynor, J.O. (1969). Future orientation and motivation of immediate activity: An elaboration of the theory of achievement motivation, Psychological Review, 76, 606-610.
[10] Weiner, B., Frieze, I., Reed, L. & Rosenbaum, R.M. （1971）. Perceiving the cause of success and failure, New York General Learning Press., 95-120
[11] Deci, E.L. (1980). The psychology of self-determination. Lexington, Massachusetts., D.C. Heath (Lexington Books).
[12] DCharms, R. (1968). Personal causation: The international affective determinations of behavior, New York: Academic Press.
[13] Bandura, A.L. (1977). Social learning theory, Morristown, New Jersey: General Learning Press.
[14] Ichihara, Y., Miyagawa, Y., Shimada, K., & Moriyama, J. (2011). Differences in the learning motivation by field-dependent and field-independent cognitive style in tech-nology education, Research bulletin of factory of education and welfare science, 31(1), 89-96.
[15] Muramatsu, H., Kawamata J., Yamaguchi, O., & Mori-yama, Jun. (2009). Effects of Intellectual Property Learning Using Information Sharing System by CMS in Junior High School Technology Education, Journal of the Japan Society of Educational Information, 25(3), 41-49.
[16] Fujikawa, S., & Andoh, S. (2011). Development and practice of a subject, "interior lamp of blue LED", to cultivate interest in, and positive attitudes toward the study of energy conversion, Journal of the Japan Society of Tech-nology Education, 53(2), 107-114.
[17] Yoshida, M., Obara, M., & Hamada, Y. (2007). A teaching tool with PIC in solar battery, Journal of the Japan Society of Technology Education, 49(4), 273-278.
[18] Kawamata, J.., Yamaguchi, H. Muramatsu, H. et al. (2007) . Utilization of information sharing system and effectiveness of cooperative learning in manu-facturing robots in technology education in junior high school, 23th annual meeting of Japan Society of Educational Information, ,256-257
[19] Yamamoto, T.., Taga H., Shinya, C., et al. (2007), Proposal of Problem of Programming in the Cooper-ation Learning－Programming Learning for Adopt-ed the Curling Game－, Study on Educational In-formation, 22(3), 11-17.
[20] Furuya, S (2010). Development of language ability with NHK digital teaching materials "Tsutaeru Gokui", Practical research for education, 3, 19-26
[21] Mochiduki, K.., Kuramochi, k. Kaneko, k., et al.(2010). Teachers' strategy on home economics lesson of linguistic activity with infants' dialogue material: focusing on the classroom "discourse". Journal of the Japan Society of Home Economics Education, 54(3), 155-164.
[22] Ministry of Education, Culture, Sports, Science and Technology (2008): Improvements of Course of Study in kindergartens, elementary schools, junior high schools, senior high schools and special needs schools (report) p.25, Retrieved November 27, 2011, from http://www.mext.go.jp/a_menu/shotou/new-cs/news/20080117.pdf.
[23] Vygotsky, L. (1978). Mind in society: The development of higher psychological processes. Cambridge: Harvard University Press.