Energy Technology: A Cross-Curricular Approach in Japan

Sadato Yamazaki, Cyril King, Mika Shinde, Osamu Ohiwa, and Sohichiro Hirai

This article briefly describes a curriculum study that had two main purposes. The first purpose was to develop and reflect upon a new energy technology curriculum at the lower secondary school level using an action research method. The second purpose was to determine the effect of collaborative activities, with the families of the pupils enrolled in the curriculum, as a means to help develop pupils' cross-curricular competence.

Yamazaki (1999a, 1999b), Yamazaki and King (1998), and Yamazaki, King, and Preitz (2000) proposed conceptual frameworks for curricular themes and activities for technology education based on a whole curriculum concept. The authors gave serious consideration to both accountability and collaboration between the school, family, and community. In order to emphasize the interdisciplinary relationship between each technological activity and other subject areas, the authors introduced four intra cross-curricular technology themes as a general education experience from kindergarten to upper secondary school: (a) developing resources, processing materials, and making products; (b) converting, transmitting, and conserving forms of energy; (c) processing, transmitting, and controlling information; and (d) developing and conserving biological resources.

In addition, it was recognized that technology instruction involves the following creative, problem-solving processes: identifying technological problems to be resolved; planning, designing, and communicating; manufacturing; and reflecting on technology and assessing the impact on the environment and society.

Ohnuma, Takahashi, Kasahara, and Yamazaki (1997) and Yamazaki et al. (2000) identified, through action research, the importance of three inter cross-curricular themes throughout formal, nonformal, and informal education: environmental study; foods, human health, and life skills; and mutual understanding between communities as well as international societies.

The Japanese Society of Technology Education (JSTE, 1999) also proposed two frameworks for providing opportunities in technology education as a general education for all, from kindergarten through upper secondary school. Four technology related curricular themes were identified as being closely associated with technology education: working with materials and processing technology; energy conversion technology; information, systems, and control technology; and bio-related technology.

We propose technological processing as a fifth curricular theme closely associated with technology education (see Figure 1).

Figure 1. Systems approach of technological problem solving in action

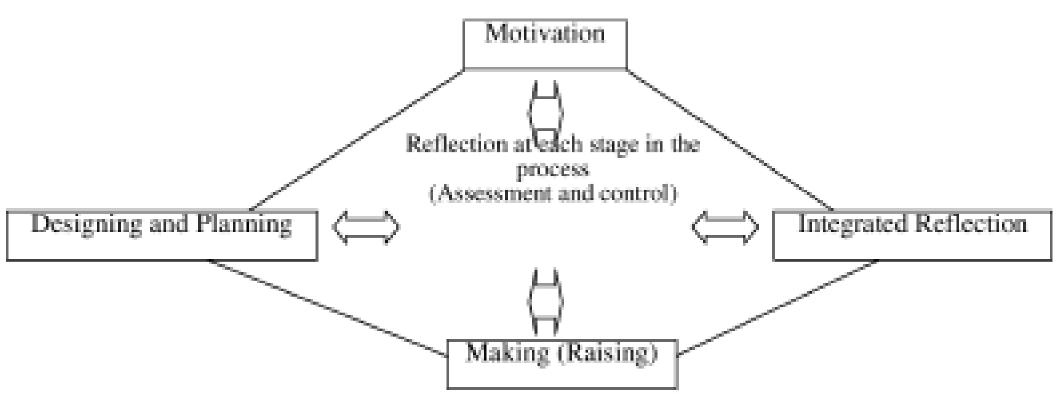

Table 1. Curriculum and Modules

First term (total of 6 class hours in grade 8)	
Module 1	Is the plug receptacle (socket) in your home really safe?
Module 2	Let's make an electrical extension lead.
Module 3	Let's develop an instruction sheet on how to use home electricity safely.
Second term (total of 18 class hours in grade 9)	
Module 4	Let's study electrical energy utilization in an earthquake disaster.
Module 5	Let's investigate wind, thermoelectric and atomic power stations in Joetsu district.
Module 6	Let's generate electricity by a hand-powered generator.
Module 7	Let's make a germanium radio without electric power.
Module 8	Let's make a radio with an emergency light generated by hand power.
Module 9	Let's consider how to use the radio to provide against contingencies.

Table 2. The Results of ANOVA Analysis in Each Comparison Between Pre and Post Self- Assessments

[1] Variables of capabilities about inter cross-curricular themes		
(3)	Safe management of natural resources and environmental preservation in home life, as a pupil makes all the members of own family understand and cooperate	A X C: 7.88** B: 2.85+
(4)	Using electrical appliances in a safety conscious way	A: 4.22*
(5)	Explanation about prevention of electrical disasters and safety regulations	C : 11.93**
(6)	Using electrical appliances with consciousness about environmental preservation	A: 6.16* B: 4.16*
(7)	Explanation about relationship between electricity and natural resources or environmental preservation	C: 4.19*
[2] Variables of capability of electricity in technology education		
(2)	Putting knowledge and skills, which the pupil studies in technology classroom, to practical use	C: 4.24*
(8)	Interest in assembling and repairing electrical appliances	C: 4.24*
(9)	Handling and good management of an electrical extension lead	C: 39.33**
(10)	Interest in the study of electricity	A X B: 4.79*
(11)	Understanding that it is dangerous to use electrical appliances inappropriately	A X C: 4.57*
[3] Variables of capability of portfolio study		
(12)	Bringing and using portfolio on electricity study for homework	Ns
(13)	Putting portfolio on electricity study to practical use	Ns
(14)	Writing and making portfolio to review in class	A: 8.77** B: 6.48**
(15)	Preparing study using portfolio	B X C: 4.02*
[4] Variables of capability of collaborative study with own family		
(1)	Collaborative study on portfolio in technology education with own family	A X B X C: 2.65 +
(16)	Review, with comments from own family about portfolio	C: 8.55**
(17)	Communication skills to make own family engage in the collaborative study	C: 5.59*

+ $p < .10$. * $p < .05$. ** $p < .01$.

Note 1:
Factor A: a comparison between a class of self-study and a class of collaborative study with pupil's family; Factor B: a comparison between higher, middle, and lower levels of achievements in technology education; Factor C: a comparison between pre and post self-assessments.

Note 2:
The number of pupils in the class of self-study was 38 (male 18, Female 20). The number of pupils in the class of collaborative study with the family was 38 (male 19, female 19).

Action Research

The Niigata and Ibaraki Prefectural Technology and Homemaking Teacher Research Associations, which are members of the All Japan Technology and Homemaking Teacher Research Association, cooperated in this action research. Teachers of the Naoetsu and Chiyokawa Public Lower Secondary Schools also collaborated in this study from 1996 to 1999. Naoetsu Lower Secondary School is located on the west coast of Honshu, the Sea of Japan side of the island. Chiyokawa Lower Secondary

School is located in Ibaraki prefecture next to Tokyo's metropolitan district. Participants were Grade 8 and 9 pupils who were enrolled in a compulsory course in technology and homemaking. The analysis of data was based on two Grade 8 classes in Naoetsu Lower Secondary School.

Curriculum and Modules

The curriculum and modules used within this study are shown in Table 1. Since the schools in this study were not authorized by the Ministry of Education Science, Sports and Culture of the Government of Japan as curricular experimental schools, the statutory course of study for lower secondary schools issued in 1989 (Ministry of Education Science, Sports and Culture, 1989) was adhered to in this study. Accordingly, we developed a school-based curriculum for use in the two schools.

As part of the study, we developed curriculum content links between the lower secondary school compulsory subject areas of technology and homemaking, and science. The technology and homemaking subject area requires pupils to study woodworking and home living at Grade 7, and electricity, food, and another three topics at Grades 8 to 9.

Another key aspect of the study was the production of portfolios of study by the pupils. We proposed that the production and use of these portfolios would help pupils develop competence in both technological creative processes and collaborative study.

Quantitative Approach

This article reports on the quantitative and qualitative studies undertaken in Term 1. In order to investigate the effect of collaborative study with the pupils' families in the development of the curriculum, a three (A x B x C) factorial design research was carried out as part of the main research from October to November 1998 (see Table 2).

Factor A compared a self-study group and a collaborative study group with the pupils' families. Factor B compared higher, middle, and lower levels of pupil achievement in technology education. Factor C compared pre and post self-assessments. Pupils were pre and post self-assessed by means of a 6-point scale in each term.

Qualitative Approach

Pupils' descriptions and comments in their portfolios of study, and interviews with some pupils, were used as assessment devices. Participants were also observed in order to collect ethnographic data in real classroom situations. Pupils also had the opportunity to give their written evaluations within two weeks of finishing Term 1.

Figure 2. The average of self-assessment as compared with self-study and collaborative groups

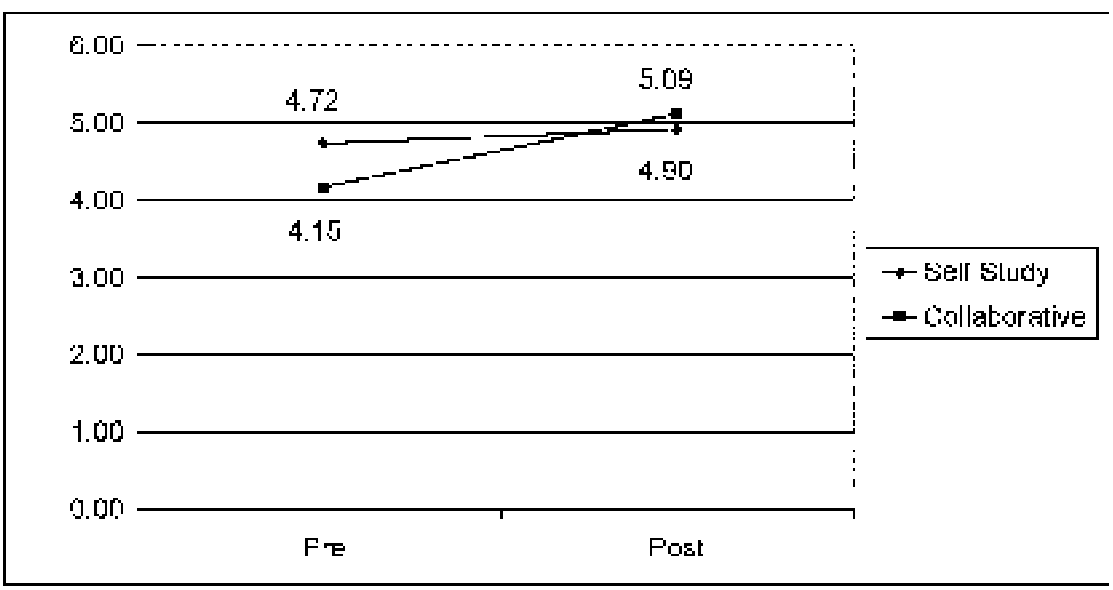

Table 3. Number of Pupils Who Commented in the Delayed Assessment on Electricity Study and How They Practiced in Real Life

Content of Pupils' Description [illegible]	Group of Self-Study [illegible]	Group of Collaborative Study [illegible]
(1) Nothing	21	9
(2) About electric power saving	5	9
(3) Corrected how to use electrical lead	4	6
(4) Do not act dangerously when using electricity	0	1
(5) Other	0	3
(6) Unknown	4	1
(7) No description	3	5

Table 4. Data of Comparison Between Pre and Post Self-Assessment in Case of Pupil W (Female)

Capability	Pre	Post
(11) Understanding that it is dangerous to use electrical appliances inappropriately	1	6
(4) Using electrical appliances in a safety conscious way	1	5
(6) Using electrical appliances with consciousness of environmental preservation	1	3

The Curriculum Approach's Effects

Statistical Results

Because it is impossible to control experimental circumstances in a general, real classroom study, it is important to interpret and apply the data on pupils' pre assessment. The technology teacher Ohiwa, one of the authors, recognized that there were not large differences in his pupils' achievement, capability, and motivation. However, the authors, including the teacher, considered that there were some different ethnographical contexts between each class. Identifying the sociocultural context of the classroom is important in undertaking action research.

The results of the ANOVA analysis between pre and post self-assessments is shown in Table 2. The data for Item 3 shows that the interaction between A (self vs. collaborative study) x C (pre vs. post) was significant. The main effect of Factor B (a degree of achievement) has significant tendency. The simple effect of Factor A was significant. The simple effect of Factor C, with a degree of error at each level, has significant tendency. Therefore, the data highlights the effect of collaborative study involving the family.

The average of self-assessment as compared with self-study and collaborative groups in Item 3 is shown in Figure 2.

Portfolios, Cases, and Interviews

Item 1 in Table 3 shows a significance between self and collaborative study with the family. In the class where pupils undertook the collaborative study with their families, nine pupils described electric power saving. It is clear that the pupils also performed as a contact person and link between the class and family.

Case Studies

A comparison between pre and post self-assessments in the case of Pupil W (female) is shown in Table 4. She gained the highest scores in Item 11 in the post self-assessment though lowest in the pre self-assessment. In addition, she produced a very good portfolio entitled "Are My Home's Plug Receptacles Really Safe?" As part of her portfolio, she made an instruction manual, in the form of a cartoon comic strip, on how to safely use and manage electricity safely.

Data for Pupil F (female) are shown in Table 5. In her portfolio, she studied how handicapped or aged people safely use electrical appliances. In addition, she paid attention to how to use electricity, taking account of environmental preservation and prevention of disasters. In the interview with her, she answered that her father was very helpful in giving her useful information.

Table 6 shows a third case study involving Pupil W (female). The topic in her portfolio

Table 5. Data of Comparison Between Pre and Post Self-Assessment in Case of "Pupil F" (Female)

[illegible]	[illegible]	[illegible]
(9) Handling and managing an electrical extension cord appropriately	2	6
(6) Using electrical appliances with consciousness of environmental preservation	4	6
(11) Bringing and using portfolio on electricity study for homework	4	6
(5) Explanation about prevention of electrical disasters and safety regulations	3	5

Table 6. Data of Comparison Between Pre and Post Self Assessment in Case of Pupil W (Female)

[illegible]	[illegible]	[illegible]
(6) Using electrical appliances with consciousness of environmental preservation	2	5
(3) Safe management of natural resources and environmental preservation in home life, as a pupil makes all the members of own family understand and cooperate	4	6
(5) Explanation about prevention of electrical disasters and safety regulations	1	3

was how to economize in the use of electric power. She investigated the methods of saving in the use of electric power for household lights, a refrigerator, televisions, a video player, an air conditioner and its remote controller, and a personal computer. She described the dangers of putting too much load on one electric outlet. She also noted how to use instruction manuals on electrical appliances and how they should be electrically grounded. In her interview, she was pleased that she undertook a beneficial collaborative study with her father in her homework because he was employed by an electricity company. The results show that both intra and inter cross-curricular approaches, together with collaborative study with the family, are very effective in developing transdisciplinary competence.

What We Believe the Study Indicates

It is clear that the indigenous and school-based cross-curricular approaches in energy technology developed in this study are effective.

This study has shown some evidence of the educational benefits of pupils' collaborative study with their families in energy technology.

The development of a portfolio is a very efficient study method in helping pupils develop cross-curricular competence.

Dr. Sadato Yamazaki is an associate professor in the Department of Learning Support, Joetsu University of Education, Japan. He is a member of the Omicron Field chapter of Epsilon Pi Tau.

Cyril King is an advisor in the South Eastern Education and Library Board, Belfast, United Kingdom. He is a Member-at-large of Epsilon Pi Tau.

Mika Shinde is a technology teacher in the Kanazawa Lower Secondary School, Kanazawa, Japan.

The late Osamu Ohiwa was a technology teacher in the Naoetsu Lower Secondary School, Joetsu, Japan.

Sohichiro Hirai is currently an inspector in the Ibaraki Regional Committee of Education.

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