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Development of a teaching plan integrating multiple subjects in IT education and an analysis of student motivation

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Abstract

We developed an IT education teaching plan or used in an information and computers unit of 9th grade (3rd year Junior High) Industrial Arts & Home Economics that introduces topics from multiple subjects and incorporates learning content that increases learner motivation and can be tied to other subjects with clear objectives for application. Quantitative analysis of the effects of this teaching approach on student motivation showed that the motivation scores were high for the three scale items of occurrence of cognitive conflict, stimulation of intellectual curiosity and degree of association in the subjects of Math, Science, and Social Studies. Analysis of differences of subjects showed that scores for stimulation of intellectual curiosity were higher in Science compared to Math and Social Studies. Qualitative analysis suggested that students experienced a deeper understanding of subject matter in the process of entering data and generating graphs on their own to answer a specific question rather than simply interpreting finished graphs and distribution maps as they would in a standard class.

1. Problem and Background

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) announced revisions to the national curriculum guidelines for junior high school in March 2008 (MEXT, 2008). Under General Provisions, Section 4 denotes important elements in the instruction programs for all subjects, including, "use of audiovisual teaching materials and equipment in learning activities that instill a sense of information technology (IT) ethics and encourage students to independently make active and effective use of computers and information and communication networks." This illustrates how there is now, more than ever, an increased emphasis on multidisciplinary approaches to information technology (IT) education and use of ICT in learning activities.

The objective of using ICT (Information and Communication Technology) in classrooms is to raise student understanding and interest in the subject matter by integrating computers, projectors, and other

information materials across a broad range of classes. Given this recent trend in IT education, we have developed a teaching plan for a junior high school Industrial Arts & Home Economics unit on information and computers (MEXT, 2008) that integrates a number of topics from different subjects. The purpose of this empirical study is to investigate the effect of our teaching plan on the motivation of student learners.

First, let us review IT education as a system in Japan. IT is not an independent subject at the elementary school level. National curriculum guidelines for elementary school (MEXT, 2008) say only to "familiarize students with information resources" and the interpretation of this by teachers varies widely. At the junior high school level, IT education is likewise not an independent subject and in practice, is included mostly as part of a unit on information and computers in Industrial Arts & Home Economics. In this context, the majority of time in IT education is spent on teaching students how to operate information systems and to use software. IT education is not integrated across different subjects (Toyoda & Nonaka, 2001; Okugi & Furuta, 2005; Sugie and Osaki, 2007; Kakihana, 2007; Yamazaki, Minamishima & Hasunuma, 2003; Kitou • Moriyama & Matsuura, 2005).

At the same time, it has been reported that children are not satisfied with their current computer and IT education environments. While they strongly want more time and more opportunities to master computer skills, they have a weak sense of a concrete objective when it comes to why they want to have these skills or what they want to do once they have them. For students to use computers as tools and accurately determine how they should be used, it important that they have opportunities to practice in a variety of learning situations as well as an educational aim in their exploration (Nagano, 1998; Nakagawa, 2000; Araki, Saito & Oiwa, 1996).

Thus, the following two approaches are essential for IT education today: 1) learning content that increases learner motivation, 2) integration across subjects, 3) an educational objective for application. We have developed an IT education teaching plan that introduces topics from multiple subjects (Math, Science, and Social Studies) for use in the information and computers unit of 9th grade (3rd year Junior High) Industrial Arts & Home Economics. We empirically determine how learner motivation changed as a result of classes implementing this teaching plan.

2. Method

2-1. Survey subjects

The participants in this study were 14 students in a single class at a private junior high school in Kanagawa prefecture.

2-2. Survey procedure

The Industrial Arts & Home Economics information and computers unit were taught over a total of 6 hours. A questionnaire survey was used to measure changes in motivation after completion of each class. For each of the Math, Science, and Social Studies topics, we measured occurrence of cognitive conflict, stimulation of intellectual curiosity, and degree of association on a scale of 1 to 5, with 5 being the most affirmative response and 1 the most negative. Students were asked to circle their responses on the motivation scale and write free responses.

2-3. Classes introducing topics from multiple subjects

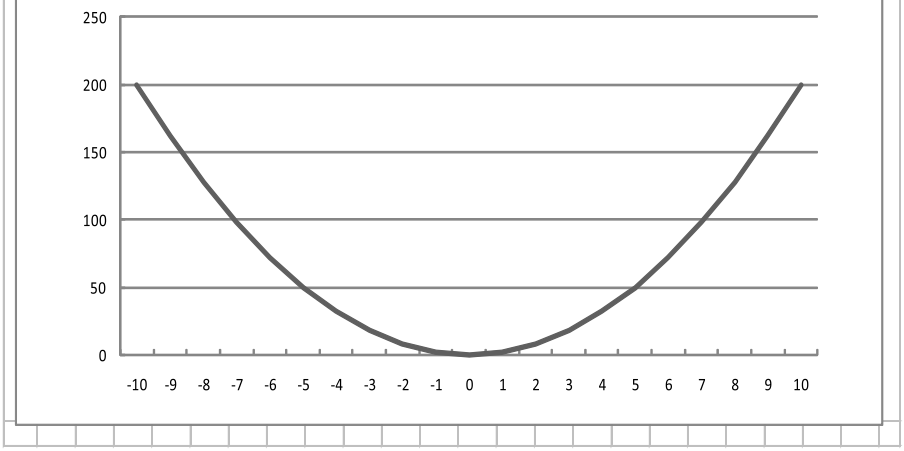
Hour 1, Hour 2, and Hour 3 consisted of instruction on basic spreadsheet functions (names of various items, how to insert, delete, and move sheets and change their titles, insert and delete rows and columns and change their widths, change font and cell colors, and place and start new lines of text). Instruction for Hours 4, 5, and 6 are shown in Table 1. Hour 4 centered on a Math problem using 2-D line graph functions, Hour 5 was a Science problem using radar charts, and Hour 6 presented a Social Studies problem using scattergrams.

Specifically, the function problem in Hour 4 was: "Enter a formula in column y to produce a 2-D line graph." Students learned to use basic arithmetic and function symbols (power) to solve for the value of y when given the value of x in a change chart and how to work with fixed variables. In Hour 5, students learned to reference data on distances between the earth and sun (by month) from the almanac of the 2008 Chronological Scientific Tables and use the radar chart function to "create a graph showing the earth's orbit." The graphs illustrated how the center of the sun does not keep a constant distance from the earth. Against students' expectations, it is in fact further away in the summer and closer in the winter. In Hour 6, students learned to use U.S. Geological Survey (USGS) data to create scattergrams to illustrate earthquakes on the planet. Students used dots to mark latitude and longitude values and saw how epicenters are distributed in belts, with high concentrations in the circum-Pacific orogenic belt. This is an area where many earthquakes occur and which students first learned about in 7th grade Geology (section on natural environments in the Japan and the world in Chapter 1 of the new edition of the Tokyo Shoseki "New Geology" textbook).

Table 1 Instruction introducing topics from multiple subjects (1/2)

4h	

x	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
y	200	162	128	98	72	50	32	18	8	2	0	2	8	18	32	50	72	98	128	162	200

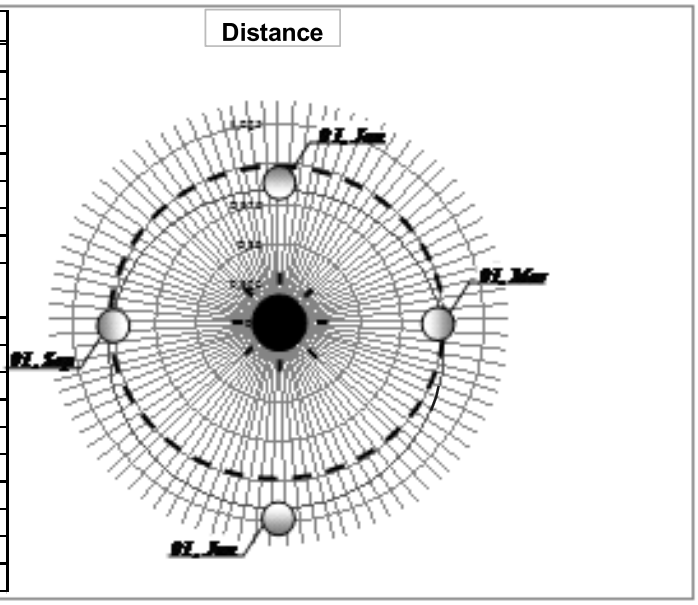


2-D Line Graph (Mathematics)

Table 1 Instruction introducing topics from multiple subjects (2/2)

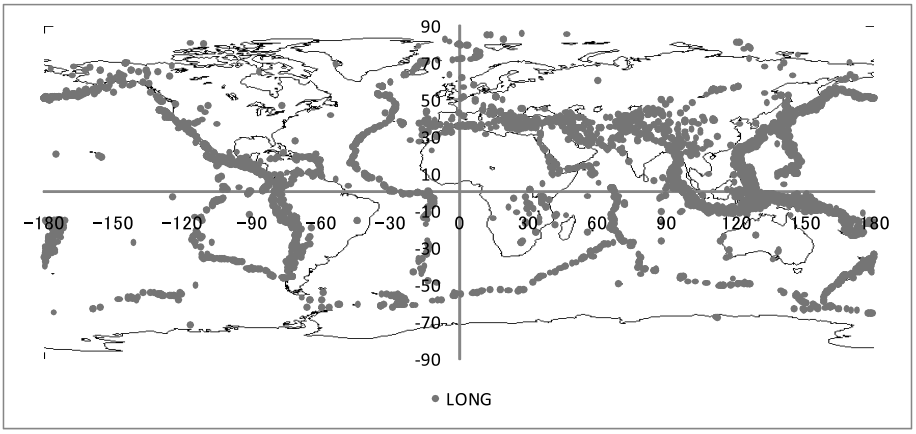
5h

No.	Month	Day	Distance
1	1	1	0.98332
2	1	3	0.98328
3	1	7	0.98331
4	1	11	0.98341
5	1	15	0.98357
6	1	19	0.98381
7	1	23	0.98414
8	1	27	0.98457
⋮	⋮	⋮	⋮
55	8	2	1.01487
56	8	6	1.01430
57	8	10	1.01366
58	8	14	1.01295
59	8	18	1.01220
60	8	22	1.01142
61	8	26	1.01059
62	8	30	1.00970
63	9	3	1.00874
64	9	7	1.00773



Cobweb Chart (Science)

6h



PDE	2007	1	1	121.12	10.98	−85.32	40	4.2	mb GS	.F .
PDE	2007	1	1	3145.02	1.23	67.12	10	5.4	MwGCMT	.. M
PDE	2007	1	1	3706.57	−5.57	133.85	26	5.2	MwGCMT	.. M
PDE	2007	1	1	10513.47	32.8	−39.82	10	5	MwGCMT	.. M
PDE	2007	1	1	23517.17	−18.3	−174.78	35	5	mb GS	.F .
PDE	2007	1	1	32953.71	46.25	152.96	10	4.4	mb GS	.. .
PDE	2007	1	1	44247.54	−36.35	−179.34	35	4.3	mb GS	.. .
PDE	2007	1	1	44917.41	13.4	146.05	35	4.3	mb GS	.. .
PDE	2007	1	1	45523.14	13.68	51.64	10	4.8	mb GS	.. .
PDE	2007	1	1	55732.16	−21.2	−174.47	35	4.5	mb GS	.. .
PDE	2007	1	1	82449.4	16.78	−100.33	15	4.7	MDUNM	.. .
PDE	2007	1	1	93137.65	13.41	146.18	22	4.6	mb GS	.. .
PDE	2007	1	1	103437.9	47.1	152.6	10	4.7	mb GS	.. .
PDE	2007	1	1	104248.26	46.76	155.57	10	4.4	mb GS	.. .
PDE	2007	1	1	111458.2	−7.89	107.01	48	4.6	mb GS	.. .
PDE	2007	1	1	135337.96	−17.58	−174.34	55	4.6	mb GS	.. .
PDE	2007	1	1	145945.64	46.48	14.26	10	4.2	MLGRF	5F .
PDE	2007	1	1	151858.09	46.19	153.05	6	4.4	mb GS	.. .
PDE	2007	1	1	184139.5	17.33	−100.81	10	4.3	MDUNM	.. .

Scatter Chart (Social Studies)

3. Results and Discussion

Table 2 shows pre- and post-class motivation scores for each of the subjects (Math, Science, and Social Studies) introduced in IT education. Scores were high for all three subjects on the three scale items of occurrence of cognitive conflict, stimulation of intellectual curiosity, and degree of association. One-factor analysis of variance showed that while there was no main effect between subjects for occurrence of cognitive conflict and degree of association, there was a main effect for stimulation of intellectual curiosity ($F(2, 39) = 0.01$, $p < 0.05$). Subtest results (5% significance level with Ryan's test) showed that scores for Science were higher than Math and Social Studies.

In quantitative analysis, we reviewed free responses to the questionnaires distributed after Hours 4, 5, and 6. For occurrence of cognitive conflict, comments included: "I thought the Earth revolved around the sun at a fixed distance, so when we made the map showing distances between the Earth and the sun, I was surprised to find out that we are farthest away at the summer solstice" (5h: Science), "I thought earthquakes could happen anywhere, but when we made the scattergram I was amazed to see that they only happen on plate boundaries" (6h: Social Studies). These responses indicated that multidisciplinary IT education introduced cognitive conflict when students produced results that ran counter to their preconceptions and expectations in each subject.

For stimulation of intellectual curiosity, comments included: "When I entered the monthly sun and earth distances and created a graph, it was easy to see and fun to learn" (5h: Science), "Entering numbers into the spreadsheet and changing the latitude and longitude values into dots representing earthquakes was a fun way to get information" (6h: Social Studies). These responses indicated that intellectual curiosity was stimulated when students experienced hands-on how to use the data to create graphs for a specific purpose, unlike in standard classes where finished graphs and distribution maps were presented. They also transferred this knowledge across subjects. These types of response were especially prominent for Science.

For degree of association, one sample comment was: "By looking at a distribution map that used dots to represent the location, expressed in numbers, of earthquakes, I could see how the epicenters are in belts and I understood how plate movement is related to earthquakes" (6h: Social Studies). This response suggested that, by visualizing as a graph what would otherwise have no meaning to them, students became aware of the value of the learning process involved in using spreadsheet software and

Table 2 Average Scores for Motivation

(Figures in paratheses are standard deviations.)

Questions	Subjects Introduced			Total
	Mathematics	Science	Social Studies	
Occurance of Cognitive Conflict	3.58 (0.78)	3.93 (1.05)	4.02 (1.01)	3.82 (0.98)
Stimulation of Intellecutal Curiosity	3.88 (0.89)	4.16 (0.63)	3.77 (0.73)	4.01 (0.81)
Association of concept of probabilit	3.36 (0.73)	3.56 (0.48)	3.44 (0.69)	3.43 (0.65)

discovered that IT education could be tied to tasks in different disciplines.

In conclusion, we address tasks for future research. As we stated in our problem and purpose, there is a need for educational practice that incorporates ICT, and the goal is to heighten student understanding and to interest by integrating IT education into all classes. Our results empirically demonstrate that classes incorporating ICT may improve student motivation. As there were limits to our selected class topics and student participants, however, there is a need for further investigation with more varied elements such as grade level, subject, or software.

References

Nagano, K. (1998). "Information Technology Education for Elementary School and Learning Environment for IT". *Japan Journal of Educational Technology* 22 (suppl), 21-24.

Toyoda, M. and Y. Nonaka (2001). "How to Change Curriculum of Information and Computer in Subject of Industrial Art and Homemaking". *Bulletin of the Center for Educational Research and Training* 11, 43-50.

Okugi, Y. and T. Furuta (2005). "Development of a Scale for The Ability of Practical Use of Information in Problem-Based Learning for School Children". *Japan Journal of Educational Technology* 29(1), 69-78.

Sugie, A. and M. Osaki (2007). "Information Literacy Education in the Year 2006 Problem". *Journal of Nagoya Bunri University*, 7, 29-32.

Kakihana, K. (2007). "Learning Mathematics in an Information Literacy Education for a Remedial Class: Using Tasks with Spreadsheet Excel for Developing 'Functions Sense'". *Bulletin* of *Tsukuba Gakuin University*, 2, 15-23.

Araki, N., T. Saito and H. Ooiwa (1996). "Survey of Informatics Education in Public Junior High School". *IPSJ SIG* Notes,1-8.

Kitou, A., J. Moriyama and M. Matsuura (2005). "Structure of Students' Knowledge formed in Information Education and the Skills of Practical Use of Information: Focusing on Learning Contents at Junior High School level". *Japan Journal of Educational Technology*, 29 (Suppl) pp.29-32.

Nakagawa, M. (2000). "What is planned in IT and IT-supported education". *The Journal of INFOSTA*; Joho no Kagaku to Gijutsu, Vol.50, No.8, pp.406-413.]

Yamazaki, K., M. Minamishima and K. Hasunuma (2003). *Science Education and Information Study-An Example with Teaching Materials of Earthquake and Geosciences-*.

Monbusho (1999). *Junior High School National Curriculum for Industrial Arts & Home Economics*, Tokyo Shoseki.

MEXT (2008). *Junior High School National Curriculum for Industrial Arts & Home Economics*, Tokyo Tosho.

MEXT (2008). *Junior High School National Curriculum*, Higashiyama Shobou.

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