A Change of Industrial Technology Education Curriculum and Development of a Design Learning Support System for Technology Education

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Abstract

The Upper Secondary Education Curriculum has been reformed to cope with social changes: industry structure, working structure, the advance of science and technology, the information-oriented society, internationalization, and the aging society coupled with the declining birth rate. Great emphasis has been placed on education that encourages students to acquire basic abilities and problem-solving abilities.

The Industrial Technology Education Curriculum has been reformed as well. Upper secondary schools are being reconstituted and Specialized Courses are being reconstituted drastically. New courses that combine several Specialized Courses are also being established. It is expected that new educational methods will be developed along with new subjects and teaching methods corresponding to them.

We have developed teaching materials and a learning support system for industrial technology education based on science and for developing students' problem-solving abilities.

Introduction

The Upper Secondary Education Curriculum was reformed in July 1998 (The Curriculum Council, 1998). Upper secondary schools are being reconstituted. Furthermore, Specialized Courses are being drastically reconstituted.

So far, although industrial technology education has pursued training a corps of technicians who can work practically in industrial fields, that educational framework is being reformulated. New courses that combine several courses are being reconstituted: Manufacturing, Agriculture, Business, Home Economics, and Information study. New educational methods, new subjects, and new teaching methods corresponding to them are under development.

Until now, teaching methods that are appropriate for science education and those appropriate to technology education have existed, but a teaching method that relates technology with science is an important new teaching method.

The new curriculum is intended to help students acquire basic knowledge thoroughly along with problem-solving abilities. The new required subject of "Problem-Solving Study" was established in vocational education courses during curriculum reform in 1989. The "Period for Integrated Study" was established for elementary schools and lower and upper secondary schools in the curriculum reforms of 1998. It is aimed at helping students develop the capability and ability to discover problems individually and to solve those problems properly. As background for this, it is assumed that students' knowledge and skills acquired in individual classes will be mutually related and deepened through activities such as problem-solving.

Vocational education has allowed students to acquire problem-solving abilities through experimentation and practice. The main learning activity for solving problems is "design" in technology education. It is difficult to teach a design method to students. A typical design example is presented for students in usual design learning. Then students refer to it and solve the design subject. "Design" through this teaching method is actually a "copy" of the design example. Consequently, students often learn from a stance of passivity.

Many teaching materials using IT have already been developed to support learning. It is extremely important to combine and mesh virtual information with actual experiences in technology education. This study is intended to show how to introduce learning with actual experience into learning information using IT. This study specifically explores a way in which to teach students corresponding to learning contents and students' understandings and what kind of information must be presented for students to learn: text information, photographs, movies, graphs, and simulations using physical models.

This paper describes educational change and development of teaching materials in the Specialized Course of upper secondary education.

Curriculum Change in Upper Secondary Education

We specifically address upper secondary education. Upper secondary education is intended to help students appreciate the meanings of their own lives, develop their minds, and form the ability to choose a career and deepen their understanding of society. Depending upon students' interests, upper secondary education provides them opportunities to learn basic knowledge in the specialties of their choices and encourages them to further develop individuality and independence. Education is expected to help students develop the ability to anticipate social changes and to cope with them flexibly. It is important that a student′s academic ability is assessed according to whether or not the student has acquired a "zest for living" concomitant with the ability to learn and think independently.

School education positively conducts its activities by emphasizing the importance of motivating students to learn individually and by helping them develop abilities to learn, reason, judge, express themselves accurately, discover and solve problems, acquire basic creativity, and act independently in response to social changes. These goals require the promotion of such educational activities as hands-on learning activities, problem-solving activities, and activities to teach how to research and how to learn. Therefore, at upper secondary schools, elective subjects occupy the greater part of the curriculum; common subjects are fewer.

The national curriculum standards have been specified clearly and made more flexible so that individual schools are able to show ingenuity in developing unique educational activities to make the school distinctive. Specifically, respective schools are able to produce their own curricula in accordance with actual community situations, schools, and students. In addition, the number of elective subjects has been increased and the "Period for Integrated Study" has been

established to further promote each school′s unique educational activities.
The total number of credits required to complete upper secondary school education was reduced to 74 credits from the current 80 credits. The standard weekly credit hours for a full-time student have been reduced to 30 credit hours from the current 32 credit hours. (1 credit hour = 50 min/wk × 35 wk)

Technological Education in the General Education Course

In response to the information-oriented society, a new required subject area of "Information Study" was established in the General Education Course Curriculum. Upper secondary schools established a new general subject area, "Information Study", as a required area. It aims at helping students develop the ability to independently choose, process and send information appropriately using such information devices as computers and information communication networks.
Three subjects are established under the subject area of "Information Study". One is "Information A" presenting the use of computers and information communication networks. Another is "Information B" that promotes scientific understanding of the functions and mechanisms of a computer. One more is "Information C", which describes the role and influence of information communication networks in society. Students can choose one from among them. The only subject related to technology that students of the General Course learn is "Information Study".

The Educational Aim of the Industry Course

Now, society and the economy are changing rapidly: change of industrial structure and working structure, the advance of science and technology, the information-oriented society, internationalization, and the aging society that is occurring along with the declining birth rate. Considering these social changes, the society of the future will require specialists who can think, judge, and act independently, and who can acquire professional knowledge and skills. Therefore, it is expected that the Specialized Course of the upper secondary education help students acquire basic technical knowledge and skills necessary to work as specialists in the future.
Industrial technology education of the upper secondary school has changed corresponding to the curriculum reform of 1996. Upper secondary schools for industrial technology education had been placed on the vocational education with agricultural education and commercial education, but their courses have changed to emphasize specialized education courses for training "Specialists".
Educational aims of the Industry Course are the following.
1. Industrial technology education helps students acquire basic knowledge and skills of various industrial fields and understand their significance and function in industry within society.
2. Industrial technology education helps students acquire creative abilities and practical behavior to develop society through solving various problems of industrial technology

independently and rationally while considering our environment.

Industrial technology education helps students acquire basics thoroughly. Great emphasis is placed on experiments and practice in industrial technology education.

Learning through experimentation and practice is important for motivating students' will to learn and developing students' problem-solving abilities. These learning activities that emphasize experience must comprise the learning core in the Specialized Course of upper secondary education.

In the Specialized Course, the total number of credits required for the specialized subject areas/subjects was reduced to 25 credits from the current 30 credits. The required subjects common to every subject area are two: one comprises very basic content, whereas the other is "task-based research" for cultivating problem-solving ability. The former is "Basics of Industrial Technology", which promotes students' interest in various industries and understanding the social role of industries through practice and experimentation. The latter is "Problem-Solving" that fosters deep understanding of the knowledge and technology, while teaching the ability for solving problems.

Changes in Upper Secondary Education

Recently, students who proceed from the Specialized Course to the university have increased. From this viewpoint, technical education of the upper secondary school needs to be connected with continuous learning in institutions of higher education and work.

Percentage distribution of upper secondary school students by the type of course is the following.

General Education Course: 72.9%
Specialized Education Course: 22.1%
  Agriculture: 2.8%, Industry: 8.8%, Commerce: 8.1%, Fisheries: 0.3%
  Home economics: 1.7%, Nursing: 0.4%
Integrated education: 2.3%
Other: 2.7%

At present, 75% of the upper secondary school students go to the General Course; 25% of them continue the Industry, Commerce, Agriculture, Home Economics, and Nursing Courses. 50% of the upper secondary school students proceed to universities and junior colleges. In addition, 20% of the Industry Course students proceed to universities; 25% of them proceed to college.

Establishment of A New Course

Reconstitution of upper secondary education has been precipitated by the decrease in the population of 18-year-olds: 1994 – 1,860,000; 2004 – 1,410,000; 2014 – 1,180,000.

New courses have combined and reconstituted several courses: Manufacturing, Agriculture, Business, Home Economics and Information study. As one of them, a course based science and technology education is being established. Its educational program presumes that students learn in advanced educational institutions of universities and colleges. Development of a new educational method and a new subject and a teaching method corresponding to it are anticipated.

In the curriculum of the Specialized Course, 30–40% of the number of total credits (about 90 credits) is the number of credits for professional education; the number of credits for science and mathematics education is about 10 credits. Consequently, it is difficult to produce an educational program that maintains a close relation between science education and professional education.

Development of Design Learning Support System for Technology Education

We have been developing two packages of teaching materials based on the close relation between science and technology. One of them includes teaching material for creating an ultra-micro wind turbine. The other includes teaching materials for designing a model car.

Development of teaching materials for creating an ultra-micro wind turbine

We developed a multimedia learning support system of ultra micro-wind turbines. This system consists of teaching materials concerning fundamental knowledge and theory of wind turbines and the database. Ultra micro-wind turbines of 220-mm diameter are produced from paper. The database is produced based on experimental values of their performance (Mita, Nomura and Matsuda, 2002). In addition, a software program for predicting wind turbine performance was developed based on this database (Mita, Namiki, Nomura, Matsuda, 2003). The software program, written in Visual Basic (Microsoft Corp.), was produced based on the database. If the blade area, the fitting angle, and the wind turbine shape are determined and these buttons are clicked on this software program's interface screen, the wind turbines′ performance-predictive result is displayed.

Evaluation of teaching materials for creating a wind turbine

The teaching program shown below is planned for evaluating the teaching material on creating a wind turbine: the teaching material concerning fundamental knowledge and theory, the database and the software program. The total time required for completing this program was about 100 min.

1. Instruction of a brief review concerning the wind turbine and of the method for making the prototype wind turbine.

The problem-solving subject: Can you devise blades for producing wind turbines that can lift a weight in a short time?

2. Students learn fundamental knowledge and theory of wind turbines through teaching materials.

3. Students produce their wind turbines.

4. Students design their wind turbines while accessing data of the database. In addition,

students predict their wind turbines′ performance as designed through determination of the area, fitting angle, and blade shape.

5. Students evaluate their wind turbines′ performance.
6. A questionnaire survey is conducted with students as respondents.

Nine fourth grade students (19 years old) at our college were selected as subjects. Each student operated one computer. Questionnaire items queried students as to the relative utility of respective materials: the teaching material concerning fundamental knowledge and theory, the database, and the software program. Questionnaire responses were the following.

Q1. Is the wind turbine teaching material useful for producing wind turbines? (9 respondents)
Answer/Number: Very useful/9, Useful/0, Nothing/0, Not useful/0, Very unuseful//0

Q2. Is the wind turbine database useful for producing wind turbines? (9 respondents)
Answer/Number: Very useful/4, Useful/3, Nothing/1, Not useful/1, Very unuseful//0

Q3. Is the software program for predicting the performance of wind turbines useful for producing wind turbines? (9 respondents)
Answer/Number: Very useful/4, Useful/2, Nothing/3, Not useful/0, Very unuseful/0

Consideration: We emphasize which teaching material, the actual data of the database or the data predicted by the software program was most helpful for supporting wind turbine manufacturing; then we investigated their effectiveness. The results clarified that students feel that the teaching material is very useful. Students referred to actual data and results predicted through the software program before producing wind turbines. These students' learning activities demonstrate that the database and software program are useful as well as the teaching material.

Development of teaching materials for designing a model car

Students are interested in automobiles: their mechanisms and driving them. They need to learn many knowledge and experiments regarding technology for designing an automobile. Transmission of mechanical power was taken up as a main design subject. The car model, which can raise a 150-g mass, is a concrete design subject. This design subject includes knowledge of dynamics and technology, including force, moment of force, friction, center of gravity, motors, and gears. Text information concerning basic knowledge and theory, image information concerning the design subject and elements, analysis models based on dynamics, experiments concerning dynamics and simulation based on dynamics are all developed as teaching materials. These teaching materials are produced using a simulation and gaming system developed by Dr. Matsuda.

Contents of teaching materials for designing a model car

The design learning support system consists of the following contents.

1. Problems and Evaluation:
Problem and concept map of gravity, tension and friction
Problem and concept map of gravity and moment of force
Students solve problems and concept maps of the design subject; students' answers are evaluated by a learning support system.
2. Design:
Design subject: Let’s design a car model that can raise a mass of 150 g.
Specifications of motors and gear reduction
Design of a mechanical power transmission:
Choice of a motor, Design of a reduction gear, Traction force of a model car
Design of a center of gravity and friction force
3. Method:
Method for assembling a model car, Method of performance test
Method of measuring a center of gravity
4. Learning Contents and Analytical Models:
Gear trains and its output torque
Analytical Model of friction force acting between the tire and road
Analytical Model of force acting on a car model
Analytical Model of force transmission in the gear train
5. Design Check Sheet:
Motor performance: Output torque and electric current
Gears and a gearbox: Number of teeth and transmission ratio
Driving force of driving wheels or traction force of the model car
Judgment: Is the driving force stronger than 150 gw or not?
Model car mass, Gravity center of the model car
Reaction force acting on driving wheels, Frictional force acted on driving wheels
Judgment: Is the frictional force stronger than 150 gw or not?

Script of the teaching material for designing a model car

Students solve the design subject through the following script.
1st Stage: The design subject is presented for students.
2nd Stage: Students solve basic problems related to the design subject.
Answer and judgment: Right answer •1st Stage•3rd Stage; Mistakes•Retrial
3rd Stage: Students confirm the specifications of parts used for producing the model car. Then they learn gears and gear reduction and solve basic problems of gears.
Answer and judgment: Right answer •1st Stage•4th Stage; Mistakes•Retrial
4th Stage: Students determine the required traction force of the model car and the frictional force
acting on the driving wheels.
Answer and judgment: Right answer •1st Stage•5th Stage; Mistakes•Retrial

5th Stage: Students grapple with the design subject.

Judgment: Design completion •1st Stage•6th Stage

Students can not design the design subject.•1st Stage•They select among learning materials individually and learn the basic skills of design.

•Retrial

6th Stage: Students check their own design sheet.

Judgment: Design completion •1st Stage•7th Stage

Students misconceive the design subject.•1st Stage•They select among learning materials individually and learn the basic skills of design.•Retrial

7th Stage: Students assemble the model car and test its performance.

Judgment: Design completion, the car model can raise the weight. •End.

The car model can not raise the weight.•1st Stage or 5th Stage•

They select among the learning materials individually and learn the basic skills of design, or Redesign•Retrial

Learning materials: The above-mentioned contents of teaching materials: 2, 3, and 4.

Information regarding dynamics and technology that is necessary for solving the design subject is presented to students corresponding to the evaluation results. Again, knowledge, learning information through experiments, and analytic models are presented to students corresponding to the evaluation results. Students solve the design subject through these learning processes.
Hence, using this developed system, we can verify the relation between students' learning activities and learning information, and then report the results.

Conclusion

This report described curriculum reform and changes of Specialized Course education in upper secondary schools. In addition, development of teaching materials that are closely related to science and technology for corresponding to those changes was described. Results of practice using the developed teaching materials clarified that the teaching materials are useful for teaching basic knowledge. Nevertheless, it remains unclear whether actual data based on experiences and the analytical model based on scientific theories are effective in the learning process. Therefore, we will improve the learning support system and study the effectiveness of the learning information in the teaching-learning process of industrial technology education.

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